

## **CSM Unit 4**

### **Coeur d'Alene Lake**

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## ABBREVIATIONS AND ACRONYMS

CDALakeSeg	Coeur d'Alene Lake Segment
cfs	cubic foot per second
cm	centimeter
CSM	conceptual site model
$^{\circ}\text{C}$	degree Celsius
DIN	dissolved inorganic nitrogen
DOC	dissolved organic carbon
DOP	dissolved orthophosphorus
FS	feasibility study
IDEQ	Idaho Division of Environmental Quality
kg	kilogram
km	kilometer
$\text{km}^2$	square kilometer
m	meter
$\text{m}^3$	cubic meter
mg/kg	milligram per kilogram
mL	milliliter
NGVD	National Geodetic Vertical Datum of 1929
RAC	Remedial Action Contract
$\mu\text{g cm}^{-2} \text{ yr}^{-1}$	microgram per centimeter per year
$\mu\text{g/L}$	microgram per liter
$\mu\text{m}$	micrometer
$\mu\text{S/cm}$	microsiemen per centimeter
ppm	parts per million
PRG	preliminary remediation goal
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
SL	screening level
USGS	U.S. Geological Survey
WWII	World War II

## 1.0 INTRODUCTION

Coeur d'Alene Lake occupies the drowned river valley of the Pleistocene Spokane River and its principal tributaries, the Coeur d'Alene and St. Joe Rivers. The lake is a naturally formed lake. The construction of the Post Falls dam allowed for raising of the lake level. The outlet of the lake is the Spokane River at the northern end in the town of Coeur d'Alene, Idaho. The water quality of Coeur d'Alene Lake has been impacted by sediments, heavy metals, and other pollutants resulting from extensive mining operations in the Coeur d'Alene River basin, ongoing timber harvest activity, and nutrient inputs from urban and domestic sources proximal to the lake (Woods and Beckwith 1997). Concentrations of metals in the water of Coeur d'Alene Lake often exceed ambient water quality criteria, but not necessarily at all locations or even at all depths at any given location. Additionally, concentrations of metals in sediments from the lake exceed the ecological thresholds for the protection of benthic invertebrate communities.

The lake supports populations of aquatic life including several valued species of fish that provide recreational fishing based mainly on either planktonic food chains in open water, or littoral (near shore) food chains in shallow water. It is also a popular recreation area for many types of water sports.

Except for fill for ballast for the Union Pacific Railroad, local spills of ore and concentrates being transported to and from the Coeur d'Alene River basin, and small mines in the Wolf Lodge Creek watershed, there are no primary source areas in the Coeur d'Alene Lake area. The Coeur d'Alene River is the overwhelmingly dominant source of metals to Coeur d'Alene Lake. Metals enter the lake from the river as dissolved metals, particulate metals on fine suspended solids, and as larger particles in bedload. It has been estimated by the U.S. Geological Survey (USGS) that approximately 75 million metric tons (49.7 million cubic yards) of metals-contaminated sediment reside on the bottom of Coeur d'Alene Lake. This includes the quantity of contaminated sediment in the delta of the Coeur d'Alene River, which has been estimated at approximately 3 million cubic yards (Bookstrom 2001).

Within the area adjacent to Coeur d'Alene Lake, there have been very few previous clean-up actions. The 1996 Coeur d'Alene Lake Management Plan was developed to outline measures to address the condition of the Lake, however, it is not known if these measures have been actively implemented (CLCC 1996 and Gunderman 2000). For reference, the executive summary of the Coeur d'Alene Lake Management Plan, which includes qualitative and quantitative water quality goals, is included as Appendix K. In 1999, the USDA Forest Service performed a CERCLA time-critical removal action to remove contaminated soils and waste rock/ore dumps from the

Silver Tip Mine on Varnum Creek and the Gray Wolf Mine located on Beauty Creek, tributaries of the northern portion of Coeur d'Alene Lake. Approximately 3,000 cubic yards of material were removed from these sites and placed into the combined waste containment in the Moon Creek watershed. This action also included two portal closures and installation of a limestone drain at the Silver Tip mine to intercept acid mine drainage (Johnson 1999).

As a part of the Consent Decree for the UPRR Wallace-Mullan Branch, contaminated soils and ballast within the UPRR ROW along the Lakeshore south of the Coeur d'Alene Reservation boundary Harrison are to be removed and properly disposed of. Sampling is currently being performed to determine the extent of removals, and also the need for potential sediment removals or other remediation for the wetlands in this area; the removals are scheduled for the 2001/2002 field seasons (MFG 2000). North of the Coeur d'Alene Reservation boundary Harrison, asphalt and soil barriers are planned for the rail embankment, along with placement of an 18-inch thick sand barrier over the public beach in Harrison. Implementation of this portion of the UPRR Response Action is also planned for the year 2001/ 2002 (MFG 1999).

This watershed is assigned to conceptual site model (CSM) Unit 4 (see Part 1, Section 2, Conceptual Site Model Summary). The watershed itself has been divided into three segments; each include both lacustrine and palustrine habitats (Figure 1.1-1). A brief description of the entire watershed is presented below.

## **1.1 WATERSHED DESCRIPTION**

Segment CDALakeSeg01 includes the southern end of the lake below the mouth of the Coeur d'Alene River. It is substantially influenced by the inflow of the St. Joe River. The St Joe River was included as a component of CSM Unit 4 to account for nutrient inputs. Nutrient input to Coeur d'Alene Lake has been raised as an issue with regard to release of metals from contaminated sediment.

The trophic status (level of nutrient enrichment and phytoplankton production) of Coeur d'Alene Lake could change to the point where increased production of phytoplankton would cause reductions of oxygen levels in the deeper waters of the lake. This could allow the release of metals associated with oxyhydroxide precipitates found on the surface of the lake sediments. A nutrient load/lake response model showed that the lake has substantial capacity for increased nutrients without causing the reductions in oxygen that might cause enhanced releases of metals (Woods and Beckwith 1997).

Segment CDALakeSeg01 has some contaminated sediment at depth, but that is mainly limited to the northern third of the segment. Concentrations of metals in the water generally do not exceed the ambient water quality criteria. Some areas in the shallow extreme southern end of this segment have been observed to have reduced concentrations of dissolved oxygen during the summer months.

Segment CDALakeSeg02 includes the main body of the lake, extending from the mouth of the Coeur d'Alene River to the north end of the lake at the head of the Spokane River, excluding the Wolf Lodge Bay arm of the lake. This segment receives most of the metals input to the lake and has the largest amount of contaminated sediment. Concentrations of dissolved metals, notably lead and zinc, exceed the ambient water quality criteria more often in this segment than in other parts of the lake.

A varying fraction of the metals entering Coeur d'Alene Lake are retained within the lake. Retention (input from the Coeur d'Alene River minus output by the Spokane River) of particulate metals is high, with up to 80 to 90 percent of the total lead being retained. Retention of dissolved metals entering the lake is lower, and depends on the metals being converted to particulate form and settling to the sediment (Woods 2000). Over part of 1999, about 80 percent of the dissolved zinc entering the lake exited via the Spokane River. Some metals that reach the sediment in particulate form are subsequently released in dissolved form, mainly by diffusion from the sediment to the overlying water. The export of dissolved metals by the Spokane River is the net result of the processes of transport of dissolved metals through the lake, particulate settling, diffusive release from the sediment, and "short-circuiting" the lake by floating plumes from the Coeur d'Alene River.

Floating plumes result from temperature differences between lake water and water entering the lake from the Coeur d'Alene River. Depending on the differences in density caused by the different temperatures, the metals-contaminated plume may sink or float without completely mixing with lake water. According to studies by the USGS, a floating plume is the most common condition. When this happens during periods of high flow in the Coeur d'Alene River and St. Joe River, dissolved metals and some metals-contaminated particulates are carried to the Spokane River at the north end of the lake without mixing completely with lake water.

Segment CDALakeSeg03 is the Wolf Bay Lodge arm at the north end of the lake. There are several small mines in the Wolf Lodge Creek watershed, none of which has operated for many years. Deep sediment in Wolf Lodge Bay is contaminated with metals with decreasing concentrations toward the head of the bay. The gradient of contamination suggests that the main

part of Coeur d'Alene Lake is the source of the metals, rather than the mines in the Wolf Lodge Creek Watershed.

## **1.2 REPORT ORGANIZATION**

The remedial investigation report is divided into seven parts. This report on Coeur d'Alene Lake is Part 5, presenting the remedial investigation (RI) results for CSM Unit 4. The content and organization of this report are based on EPA's Guidance Document for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final (USEPA 1988). This report contains the following sections:

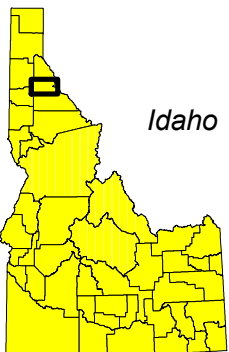
- Section 2—History
- Section 3—Geology
- Section 4—Nature and Extent of Contamination, includes a summary of chemical results
- Section 5—Fate and Transport, includes hydrodynamics of the lake and chemical and physical transport processes for metals and nutrients
- Section 6—References

Risk evaluations and potential remedial actions associated with source and depositional areas are described in the human health risk assessment, the ecological risk assessment, and the feasibility study (all under separate cover).

Figure 1.1-1  
Coeur d'Alene Lake Watershed

LEGEND

- Stream
- Road
- Interstate 90
- City
- Coeur d'Alene Lake Watershed
- River Segment
- Lake/River



Location Map

NOTES

- 1) Base map coverages obtained from the Coeur d'Alene Tribe, URS Greiner Inc., CH2M HILL, and the Bureau of Land Management.

SCALE 1:72,000  
0.5 0 0.5 Miles

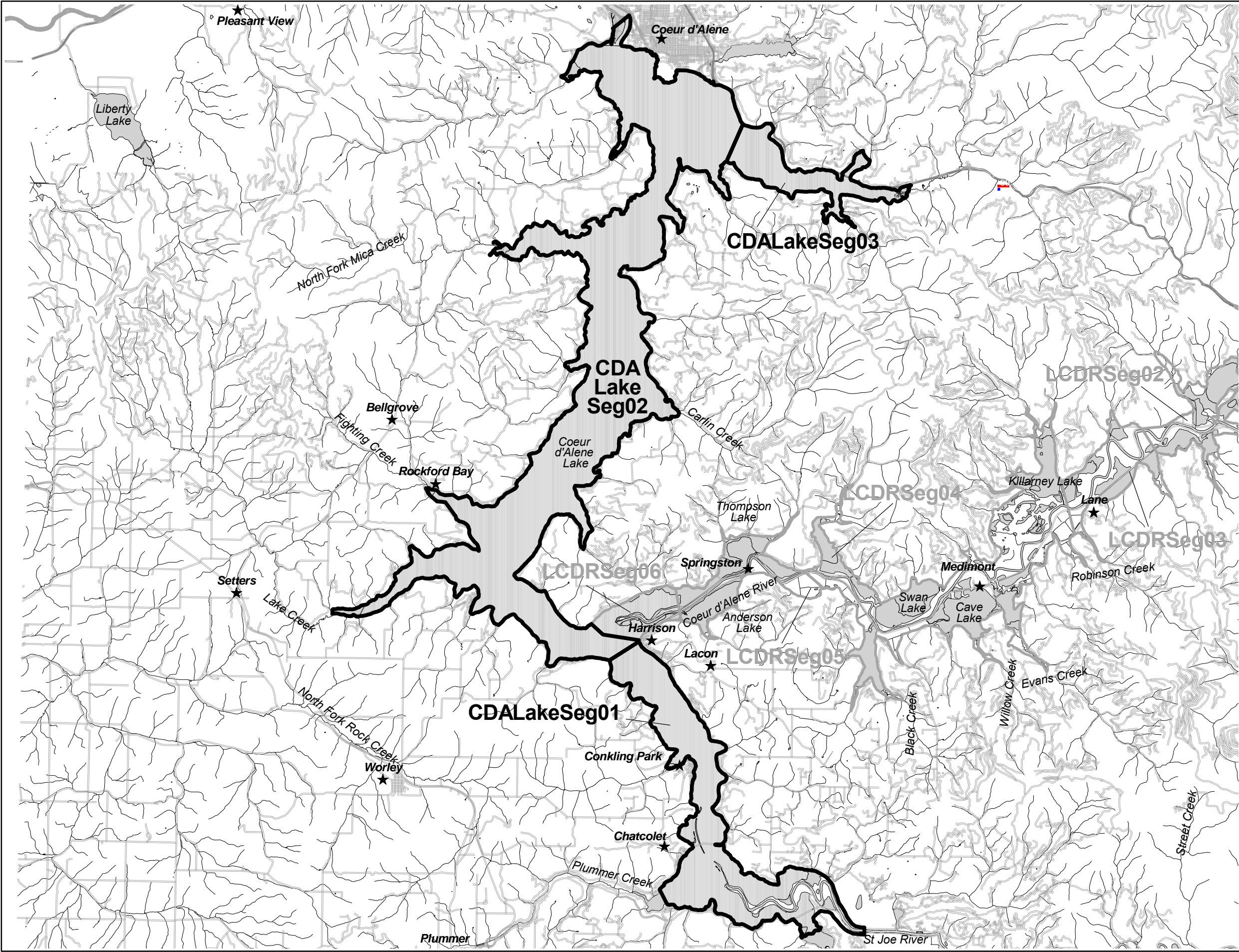


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Coeur d'Alene Basin RI/FS  
RI REPORT



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V: CDA lake  
E: CDA lake  
L: Final RI CDA lake  
7/11/2001

This map is based on Idaho  
State Plane Coordinates West Zone,  
North American Datum 1983.  
Date of Plot: July 11, 2001



## 2.0 HISTORY

The Coeur d'Alene Basin including Lake Coeur d'Alene and the St. Joe and Coeur d'Alene River Basins was the ancestral home of the Coeur d'Alene Indian Tribe for centuries prior to the coming of European immigrants in the mid- to late-1800s. Agricultural settlements developed around the Jesuit missions in the area during the mid-19th century.

The construction of a military road opened the Coeur d'Alene area for settlement by non-natives in 1859. Capt. John Mullan, supervisor of the road-building project described the lake as "a noble sheet water....filled with an abundance of delicious Salmon Trout" (Casner 1989). In subsequent years, it was also reported that early steamboat passengers on the lake would entertain themselves by throwing scraps of food to the many schools of fish. The region's abundance of fish is part of local legend. The road Mullan built, connecting Fort Benton, Montana to Walla Walla, Washington, was completed in 1862 (Hult 1952).

The present water level of the lake is regulated by the Post Falls Dam, which is located approximately seven miles from Coeur d'Alene. The original dam was constructed by Frederick Post in 1871. The dam was later purchased and replaced by the Washington Water and Power Company. The new dam increased the water level of the lake by about three feet, significantly increasing the storage capacity of the lake and flooding thousands of acres of lakeside property (Casner 1989).

In 1877, General William T. Sherman (of March-to-the-Sea and "War is hell" fame) traveled through the area while inspecting northwest forts. Sherman recommended that a military post be located near the outlet of Coeur d'Alene Lake, at the spot now occupied by the City of Coeur d'Alene. Fort Coeur d'Alene (renamed Fort Sherman after the general died) was built in 1878. Colonel Henry Clay Merriam served as the fort's first commander (Hult 1952).

Merriam could foretell the advantages of water transportation in the Coeur d'Alene region, and was able to get government authorization to build a steamboat for travel on the lake. In late 1880 the *Amelia Wheaton* was launched. Soon after, the news of A.J. Prichard's discovery of gold on Prichard Creek quickly spread, and Coeur d'Alene became the "jumping-off place" for miners headed to the "diggings." The government allowed the *Amelia Wheaton* to be used to transport miners and their outfits to the head of navigation on the Coeur d'Alene River. During periods of low water, the boat could navigate to the Cataldo Mission, while in periods of high water, navigation was possible to a point near Kingston (Hult 1952).

During the early days of the rush, freight was carried in dugouts or bateaux. Shipping charges ran as high as \$600 per ton. Realizing the potential shipping market due to traffic to the mines, two private companies began building steamers during the winter of 1883-1884. The *Coeur d'Alene* and the *General Sherman* began an intense competition to establish a shipping monopoly on the lake (Hult 1952).

Soon after the discovery of the Bunker Hill Mine in 1885, D.C. Corbin visited the Coeur d'Alene mining district. Corbin's brother was the President of the Long Island Railroad, and railroads had become his special interest. Seeing the promise of the area, Corbin envisioned a way to connect the remote mines of the region to efficient shipping channels. Corbin's plan included the construction of a narrow gauge railroad that would connect the mines to the old mission, a fleet of boats to carry shipments across the lake, and a short section of track that would connect Coeur d'Alene city to the Northern Pacific main line near Hauser Junction. The project was completed to Wardner in 1886, and a year later the tracks were completed to Wallace. Corbin then purchased the *Coeur d'Alene* and the *General Sherman*. He also built a new steamer, the *Kootenai*, capable of breaking ice up to twenty-two inches thick, and consequently keeping the lake navigable even through the winter (Hult 1952).

Other important mines continued to be discovered, and the towns of the Coeur d'Alene region were growing rapidly. The carrying capacities of Corbin's steamers were taxed to the utmost, carrying passengers, food, supplies, machinery and horses to the mines and returning with tons of ore. In 1888, the Northern Pacific Railroad bought out Corbin and all of his holdings, including the steamers (Hult 1952).

Also wanting to capitalize on the demand for shipping in the Coeur d'Alene region, the Oregon-Washington Railroad & Navigation Company built its own branch line by way of Tekoa and Harrison. This line, completed in 1890, eliminated the extra work and expense of loading and unloading steamers for the trip across the lake. The Oregon-Washington line effectively eliminated the use of steamers for shipment of ore from the mines (Hult 1952).

For a time, Coeur d'Alene Lake's role in the mining history of the Coeur d'Alene region was brought to a close. However, soon afterwards, individuals began to take notice that the lake was acting as an enormous settling basin for the waste materials discharged from the mines upstream.

In 1911, George Kemmerer of the United States Bureau of Fisheries, was conducting a study of the fisheries of the Northwest. Kemmerer noted that the muddy waters of the Coeur d'Alene River were so laden with silt that they could be traced far out into the clear water of the lake. In a 1914 navigation report of Coeur d'Alene Lake and its tributaries, the Corps of Engineers reported

that a milky material suspended in the water could be seen extending some distance into the lake (Casner 1989).

The tailings problem, which was first noticed in the lower reaches on the South Fork, began to reach the city of Coeur d'Alene by the mid-1920s. This event corresponded with the wide spread use of the flotation separation method, which generated much finer tailings, allowing wastes to be carried greater distances from the mines. The mining industry replied with assurances that nothing harmful existed and that the discoloration was due to natural erosion (Casner 1989).

Beginning in December 1929, John Knox Coe, city editor for the *Coeur d'Alene Press*, printed a series of articles in the paper on the effects of mining pollution to both the Coeur d'Alene River and the lake. The articles were, in part, spurred by Coe's observations of the Coeur d'Alene River while investigating the condition of the river with several Kootenai County Commissioners and a representative of the State of Idaho. Near the mouth of the river, the party's boat became lodged in a tailings bar. Coe reported that the boat remained lodged in the "yellow muck" for nearly an hour while the group was subjected to the "stifling stench" of the mine slimes. Coe also reported that they could watch the clear St. Joe and the dirty Coeur d'Alene River commingle, which formed a "smoky glass" that wafted towards the city (Casner 1989).

In a 1930 address to the Izaak Walton League, *Coeur d'Alene Press* editor H.F. Kretchman warned that without future action the lake would become a "replica of the mother stream which now pours day by day its slimy waters into this God-given settling tank" (Casner 1989).

In 1931, during the twenty-first session of the Idaho Legislature, Kootenai County Senator Ralph S. Nelson introduced the Coeur d'Alene pollution issue. W.V. Leonard, State Chemist, reported the findings of a study he had conducted during the previous year. Leonard also recommended that a commission be established to further study the matter (Casner 1989).

On March 16, 1931, the legislature approved an emergency act creating the Coeur d'Alene River and Lake Commission. The emergency status of the approval allowed immediate use of state funding for the commission. The commission consisted of the state Attorney General and county commissioners from both Kootenai and Shoshone counties. The emergency act required that the commission investigate the "ways and means of eliminating, so far as practicable, all industrial waste which pollute the Coeur d'Alene River and Lake." State lawmakers appropriated \$3,000 to the commission for expenses and the publishing of a report to be delivered to the 1933 session of the legislature. The U.S. Department of Agriculture, Public Health Service, and Bureau of Mines were asked for technical assistance in conducting the investigation (Casner 1989).

Dr. M.M. Ellis, of the Department of the Interior, Bureau of Fisheries was one of a handful of federal specialists who conducted studies for the newly formed commission. Ellis' report *Pollution of the Coeur d'Alene River and Adjacent Waters by Mine Wastes* was presented to the commission in 1932, although the report remained unpublished until 1940 (Casner 1989). In his investigation of Coeur d'Alene Lake, Ellis reported that the decline of the trout fishery could not be denied; however, cultivation of land, and deforestation were also discussed as contributors to the decline. Ellis stated, "Changes in the trout fauna alone of Coeur d'Alene Lake therefore can not be used as significant indices of the pollution of that lake by mine wastes from the Coeur d'Alene River until various other factors have been evaluated" (Ellis 1940).

Ellis did however find evidence of mining impacts on the lake. In July 1932, when the mines were operating only part-time, the Coeur d'Alene River exhibited a greenish hue and turbidity due to suspended slimes even at the entrance to the lake. Local residents reported that the slimes discolored the entire surface of the lake to Coeur d'Alene City. Boat captains verified these claims (Ellis 1940).

Based upon the results of an extended series of dredgings, Ellis concluded that mine slimes could be detected over practically the entire lake floor.

*It is well known to local residents that "clouds" of colloidal slimes drift across the lake moving in one direction or another, depending on the volume of wastes coming down the Coeur d'Alene River and the air and water currents acting on and in the lake at the time. The movements and volume of the colloidal clouds of mine slimes is attested by the deposits of slimes at Black Rock, where during high water they are deposited on the black rocks from which Black Rock Point takes its name. As the slimes are light in color they were easily photographed on the black rock background (Ellis 1940).*

Ellis also reported evidence of mine slimes having been washed down to Spokane River as far as Greenacres, Washington (Casner 1989).

Another report presented to the commission was completed by the U.S. Public Health Service. The study was conducted by John Kurtz Hoskins, who was a leading stream pollution expert. Hoskin's report stated that "under normal conditions the lake water is practically saturated continuously with lead in solution." The survey found that the average concentration of lead within the lake ranged from 0.08 to 0.22 parts per million (ppm). Drinking water standards at the time set a limit of 0.1 ppm for potable water (Casner 1989).

In July 1932, the mining companies responded to the public outcry by starting operations of a suction dredge system constructed below the Cataldo Mission. The dredge pumped water and fine tailings scoured from the river bottom to a dump area adjacent to the river. Water draining from the dump flowed through an area of swamps for about two miles before returning to the river system. W.L. Zeigler, of the Hecla mining company (superintendent of the Gem Mill) and designer of the dredge, claimed that water returning to the river was perfectly clear (Grant 1952).

In 1933, the commission presented its "Report and Recommendations" to the Idaho Legislature. The report concluded that the Cataldo dredge would remove a portion of the mine slimes from the river system, but recommended that the slimes be transported to settling beds by a method other than the river channel. The report recommended that a pipeline or flume be constructed to carry the waste material to the Mission Flats. This was an idea that had previously been suggested by the mining companies (Casner 1989).

The legislature took no further action at the time to remedy the problem. The mining waste problem of the Coeur d'Alene area was soon overshadowed by the Great Depression and then World War II (WWII) (Casner 1989).

Following the end of the war, the federal government resumed its course towards development of national and state pollution regulations. Anticipating the coming legislation, the State of Idaho Chamber of Commerce formed an autonomous committee to study the state's pollution problems. In 1948, the United States Congress passed the Water Pollution Control Act. With the passage of this act came a comprehensive investigation of all the nation's waterways. The nation was divided into fifteen major drainage basins. The waters of Coeur d'Alene Lake and the river were included in "The Pacific Northwest Drainage Basin Report," which detailed the Columbia River drainage, exclusive of Canada (1951 U.S. Public Health Service report, cited in Casner 1989). In an overview of the region's pollution problems, the report stated:

*Probably the greatest stream degradation to be found in the area results from the discharge of acid mine waste and tailings from ore concentration mills. The waste contains chemicals which are detrimental to normal water use, and they cause depositions which destroy aquatic life in the streams. More than 100 miles of watercourses in the Pacific Northwest have been degraded in this manner.*

The report stated that pollution damages from mining "are confined principally to the South Fork below Mullan and the Coeur d'Alene River below the mouth of the South Fork." The report also stated that the possibility of mine tailing waste affecting the water supply of Coeur d'Alene, Idaho, must be recognized (Casner 1989).

Although Coeur d'Alene Lake has served as a settling basin for more than 100 years of mining and ore processing activity, the lake has become a prime recreational site. By 1980, 80 percent of the lake's shoreline had been developed. Since that time, a 60 million dollar resort complex was constructed in the city of Coeur d'Alene. Extensive residential and commercial development of the Coeur d'Alene basin, as well as recreational use of the lake, have led to considerable concern over the potential for nutrient enrichment and subsequent eutrophication of the lake (Woods and Beckwith 1997).

A 1975 National Eutrophication Survey conducted by EPA classified the lake as mesotrophic, or moderately productive. Due to nutrient load reductions since the 1970s, the lake is currently classified as oligotrophic. Although it may appear that deposition of mine wastes in the lake and eutrophication of the lake are unrelated, it is believed that conditions caused by eutrophication may lead to the release of mining-related trace elements from the lakebed sediment (Woods and Beckwith 1997).

The remnants of past mining activities in the Coeur d'Alene basin continue to supply trace elements to Coeur d'Alene Lake.

## **3.0 GEOLOGY**

### **3.1 GEOMORPHIC SETTING**

Coeur d'Alene Lake occupies the drowned river valley of the Pleistocene Spokane River and its principal tributaries, the Coeur d'Alene and St. Joe Rivers. The outlet of the lake is the Spokane River at the northern end in the town of Coeur d'Alene, Idaho. The lake is about 25 miles long, roughly north-south, and averages about 1.5 miles wide. The maximum lake depth is about 200 feet about 5 miles south of its northern end (Woods and Berenbrock 1994). The topography along the lake is one of moderate relief, with the ridges about 1,500 feet above the lake surface within about 2 miles of the lakeshore. Elongate, topographic benches about 500 feet above the lake surface and parallel to the lake occur discontinuously between the lake and the flanking ridges along both shores.

The valley was dammed by infilling of the present Rathdrum Prairie-Spokane River valley with several hundred feet of coarse gravel deposits during a series of glacial outburst floods between about 18,000 and 13,000 years ago. These gravels underlie the northern end of the present lake. The maximum elevation of the gravel dam was about 2,360 feet above sea level, as preserved just west of the town of Coeur d'Alene. At maximum high stand of the lake, the waters of the lake backed up the Coeur d'Alene River to about one mile upstream of Kellogg (Box et al., in press) and the St. Joe River to about 10 miles upstream of Calder. The Spokane River outlet of the lake quickly eroded down through the unconsolidated gravel deposits until it encountered the hard crystalline bedrock at Post Falls, after which the rate of downcutting slowed to almost nil, stabilizing the low-water lake elevation at the present 2,118 feet above sea level. The deltas of the Coeur d'Alene and St. Joe Rivers gradually built down valley into the lake about 25 miles each after the lake elevation had stabilized, with an average rate of about 1 mile every 500 years. The backwaters of Coeur d'Alene Lake occupy the lower 25 miles of river channel in both the Coeur d'Alene and St. Joe Rivers.

The present lake elevation is controlled by the bedrock outlet of the lake on the Spokane River at Post Falls. For most of the year, the flow on the Spokane River is unregulated by the dam at Post Falls during which time the volume of flow on the Spokane River directly correlates with the elevation of Coeur d'Alene Lake. During the summer months (typically from June 15 to September 15) the outflow of the Spokane River is regulated by the dam to maintain the lake elevation at 2,125 feet above sea level. During high runoff periods on the Coeur d'Alene and St. Joe Rivers, the inflow to the lake exceeds the elevation-controlled outflow at the Spokane River and the lake level rises until the outflow equals the inflow. The lake level falls when the outflow

exceeds the inflow. The historical peak of Coeur d'Alene Lake occurred in May of 1894 at about 2,139 feet above sea level.

### **3.2 BEDROCK GEOLOGY**

The main axis of Coeur d'Alene Lake lies along a major north-striking, east-dipping bedrock fault. The rocks on the west side of the lake are highly metamorphosed quartz-rich gneisses and schists derived from original sedimentary rocks of uncertain age. Rocks on the east side of the lake are weakly metamorphosed quartz-rich sedimentary rocks of the Precambrian Belt Supergroup (Griggs 1973). Geophysical data across the fault to the north of Coeur d'Alene indicate that the fault dips about 20 degrees to the east and can be imaged down to 10 km in the crust (Yoos et al. 1991). From the fault dip and the contrast in the pressures of metamorphic recrystallization across the fault (Rhodes 1986), downdip offset along the fault is estimated to be 20-30 miles. Fault offset resulted in about 10 km of uplift of the rocks beneath the fault over a 3-5 million year period about 50 million years ago (Armstrong et al. 1987).

A major north-south topographic valley has probably followed the trace of the fault since 50 million years ago due to the erodable nature of the pervasively fractured rocks along the fault. About 15 million years ago, the Columbia River basaltic lavas flowed into roughly the present valley of the Spokane River and Coeur d'Alene Lake from the west, filling the valley with basalt. Remnants of the basalt valley plug occur as far upstream as Medimont on the Coeur d'Alene River tributary. The basalt overlies an irregular surface on the older rocks around the lake, occurring as a stack of subhorizontal lava flows that underlie the topographic bench 500 feet above lake level. Whether the basalt flows underlie the deepest parts of the lake or only crop out along the underwater walls of the lake is unknown.

### **3.3 SOILS AND SEDIMENTS**

The soils on the hillsides and terraces around the lake consist of mixtures of weathered bedrock, windblown silt (Palouse loess) blown in from the southwest during the ice ages (mostly before 10,000 years ago), and volcanic ash from recurrent eruptions of the Cascades volcanoes (including 1980 Mt. St. Helens ash) over the last 10,000 years (Weisel 1981). Loess silt deposits are generally thicker and more pervasive around the southern part of the lake, where they typically overlie benches of flat-lying Columbia River Basalt flows. Weathered soils are typically 1-3 feet thick over bedrock, but are much deeper on the loess deposits.

The bedrock valley bottom beneath Coeur d'Alene Lake is presumably 400-600 feet beneath the lake surface, based on drillhole and geophysical data from the lower Coeur d'Alene River valley (Army Corps of Engineers 1949; Norbeck 1974) and geophysical data from the Spokane River valley near the Idaho-Washington state line (Derkey et al. 1994). Even where Coeur d'Alene Lake is deepest, more than 200 feet of quaternary sediments must underlie the lake bottom. These sediments consist of a southward-thinning wedge of Pleistocene glacial outburst flood gravels that probably grade from boulder gravels under the north end of the lake to finer gravels and sands southward. This wedge is overlain by a northward-thinning wedge of recent (last 13,000 years) deltaic-lacustrine sediments derived from the Coeur d'Alene and St. Joe Rivers.

The deltaic sediments in the lower Coeur d'Alene and St. Joe River valleys consist of sand and silt deposits in the river channel and immediate riverbanks and levees. Heavily vegetated marshes with fine silt to clay extend from the levees of the river to the bedrock walls of the valley. In both the St. Joe and Coeur d'Alene River deltas, natural levees flank a channel that is 25-40 feet deep. The levees extend well out into the lake, gradually descending beneath the waters of the lake as the channel between them shallows, until they meet at a narrow river mouth bar of fine-grained sandy sediment at about 15 feet water depth. From that point, the smooth convex front of the deltas descend more steeply into the deeper parts of the lake, with the delta front sediments fining to silt as the deeper floor of the lake is reached out in front of the delta. Fine silt- and clay-sized particles, primarily derived from the St. Joe and Coeur d'Alene Rivers, make up the bottom sediments from a mile north of the Coeur d'Alene River delta to the north end of the lake (Horowitz, Elrick, and Cook 1993). The downvalley migration of the delta front produces a consistent stratigraphy in the valley fill deposits that grade (from the bottom) from distal lake deposits through delta front, river mouth bar, then either levee or marsh deposits.

Metal-enriched sediments derived from mining activities have been carried from the Coeur d'Alene River into Coeur d'Alene Lake since the late nineteenth century (Horowitz et al. 1995). Sandy to silty deposits within the Coeur d'Alene River channel near the mouth are up to 14 feet thick, while similar deposits on the river mouth bar are as thick as 18 feet (URSG and CH2M HILL 1998). Silty deposits thin rapidly away from the delta front to about 4 feet within about 3,000 feet of the river mouth bar, to 16 inches by another 2 miles northward in the lake, and to 9 inches near the Spokane River outlet (Horowitz 1995). These metal-rich lake sediments are apparently deposited from a relatively warm and buoyant, shallow water plume of suspended sediment-laden water that is carried across the lake from the Coeur d'Alene River inflow to the Spokane River outflow during high runoff periods (Paul Woods, written communication, 2000).

Sandy beaches around the lake are typically derived from wind-driven wave erosion of the local shoreline. Beaches near the mouths of the St. Joe and Coeur d'Alene Rivers are generally

composed of reworked sediment from the river deltas. At the backs of smaller inlets around the lake, beaches are derived from stream-delivered sediment of the local drainage. Around the north end of the lake, beaches are winnowed from the glacial outburst gravels that underlie the town of Coeur d'Alene.

## **4.0 NATURE AND EXTENT OF CONTAMINATION**

Data used to evaluate the nature and extent of contamination in Coeur d'Alene Lake are presented in this section. Detailed analysis of these data sets and others is included in Section 5.0.

### **4.1 NATURE AND EXTENT**

The nature and extent of the ten metals of potential concern identified in Part 1, Section 5.1 (antimony, arsenic, cadmium, copper, iron, lead, manganese, mercury, silver, and zinc) in surface soil, sediment, and surface water are presented in this section. Locations with metals detected in any matrix at concentrations 1 times (1x), 10 times (10x) and 100 times (100x) the screening level were identified.

Historical and recent investigations at areas within the study area are listed and summarized in Part 1, Section 4.0. Data source references are included as Attachment 1. Chemical data collected in Coeur d'Alene Lake and used in this evaluation are presented in Attachment 2. Data summary tables include sampling location, data source reference, collection date, depth, and reported concentration. Screening level exceedances are highlighted. Sampling locations are shown on Figures 4.1-1 through 4.1-6.

The nature and extent of contamination were evaluated by screening chemical results against applicable risk-based screening criteria and available background concentrations. Screening levels are used in this analysis to identify source areas and media (e.g., soil, sediment, and surface water) of concern.

Statistical summaries for each metal in surface soil, sediment, and surface water are included as Attachment 3. The summaries include the number of samples analyzed; the number of detections; the minimum and maximum detected concentrations; the average and coefficient of variation; and the screening level (SL) to which the detected concentration is compared. Proposed screening levels were compiled from available federal numeric criteria (e.g., National Ambient Water Quality Criteria), regional preliminary remediation goals (PRGs) (e.g., U.S. EPA Region IX PRGs), regional background studies for soil, sediment, and surface water, and other guidance documents (e.g., National Oceanographic and Atmospheric Administration freshwater sediment screening values). The screening level selection process is discussed in detail in Part 1, Section 5.1.



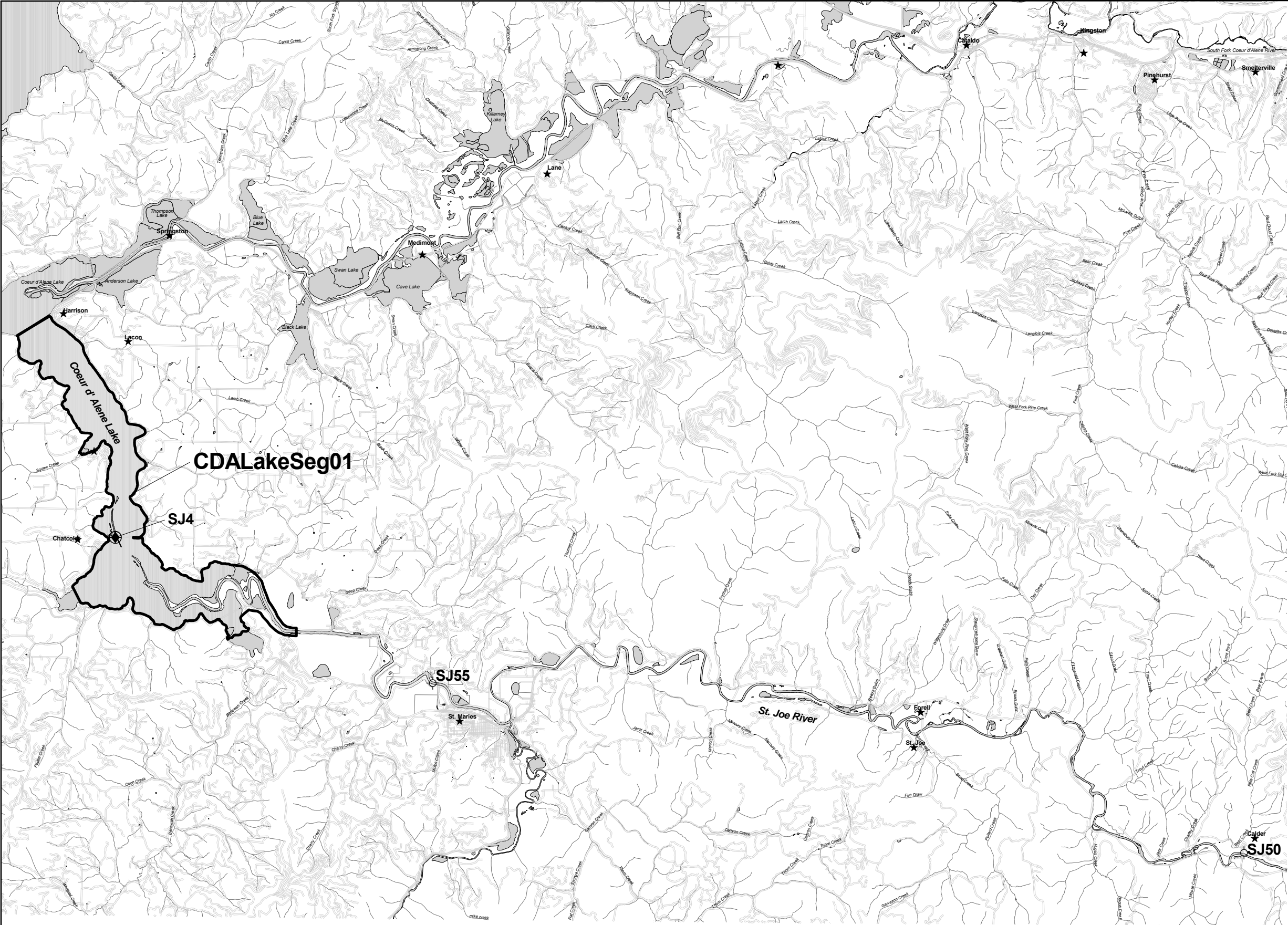
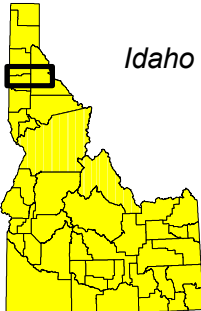


Figure 4.1-2  
Coeur d' Alene Lake Segment CDALakeSeg01  
Surfacewater Sampling Locations

LEGEND

- ◆ Lake Sampling Location
- ◇ River Sampling Location
- ~ Stream
- ~ Road
- ★ City
- CDALake Segment 1
- ▨ Lake/River/Floodplain



Location Map

NOTES

- 1) Base map coverages obtained from the Coeur d'Alene Tribe, URS Greiner, Inc., CH2M HILL, and the Bureau of Land Management.
- 2) Sampling locations obtained from URS Greiner, Inc. Technical Data Management database as of 03/29/00.

SCALE 1: 150,000

0 2 Miles



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Coeur d'Alene Basin RI/FS  
RI Report

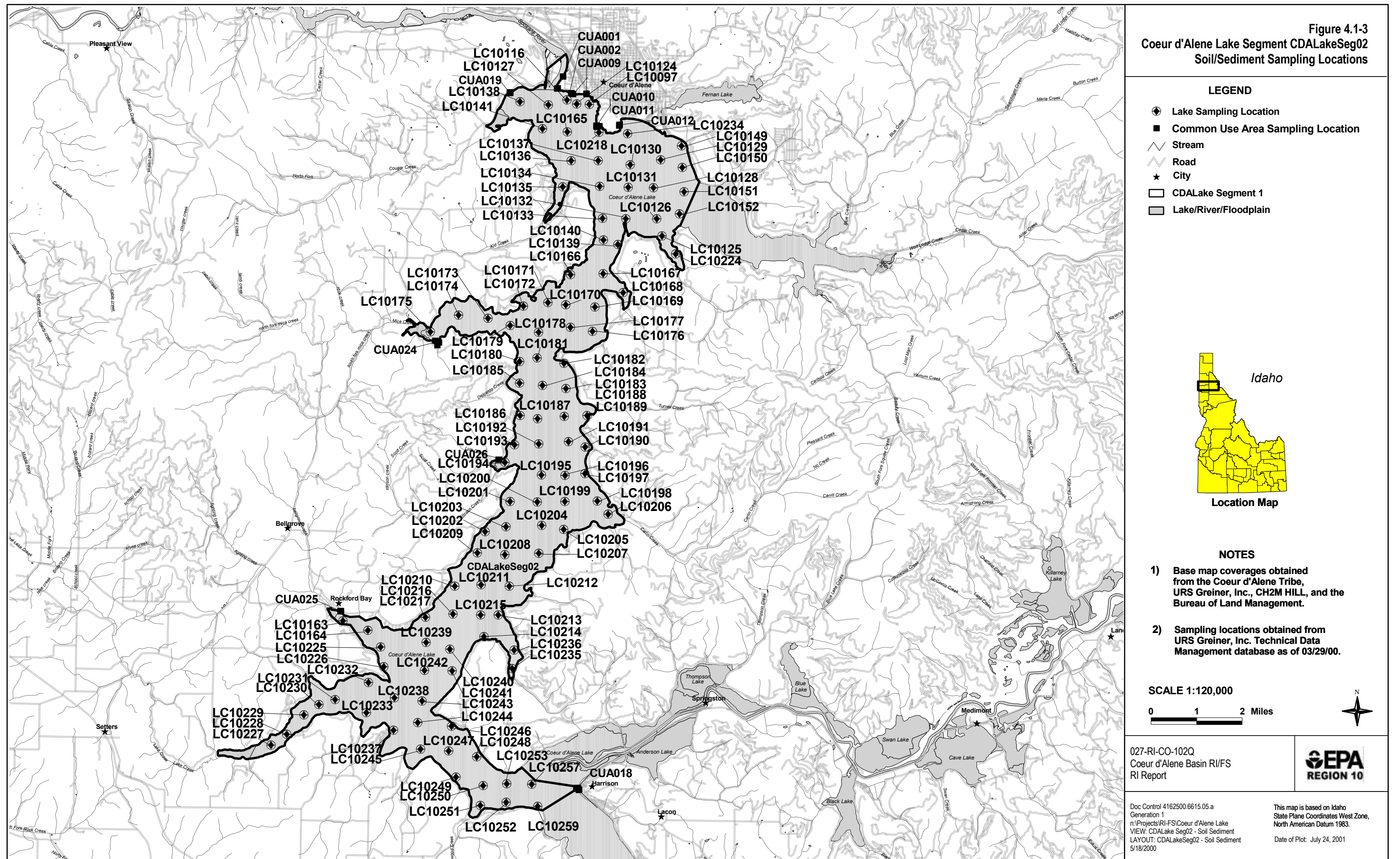


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LAYOUT: CDALakeSeg01 - Surface Water  
5/18/2000

This map is based on Idaho  
State Plane Coordinates West Zone,  
North American Datum 1983.

Date of Plot: July 24, 2001

Figure 4.1-3  
Coeur d'Alene Lake Segment CDALakeSeg02  
Soil/Sediment Sampling Locations



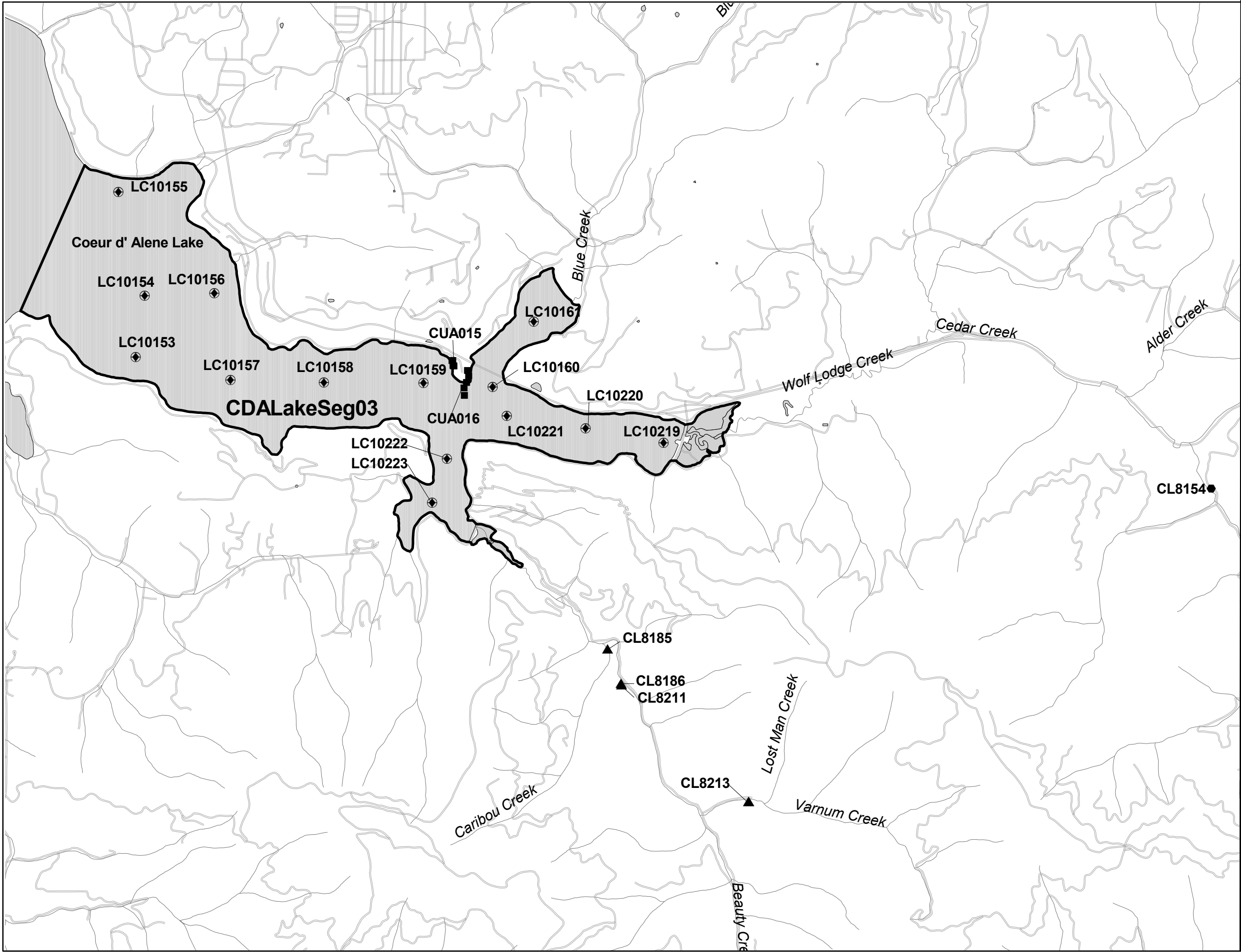


Figure 4.1-4  
Coeur d'Alene Lake Segment CDALakeSeg03  
Soil/Sediment Sampling Locations

**LEGEND**

- ◆ Lake Sampling Location
- Common Use Area Sampling Location
- Ground Surface Sampling Location
- ▲ Tailings Sampling Location
- ~ Stream
- Road
- ★ City
- CDALake Segment 1
- ▨ Lake/River/Floodplain

**Location Map**

**NOTES**

- 1) Base map coverages obtained from the Coeur d'Alene Tribe, URS Greiner, Inc., CH2M HILL, and the Bureau of Land Management.
- 2) Sampling locations obtained from URS Greiner, Inc. Technical Data Management database as of 03/29/00.

**SCALE 1:40,000**

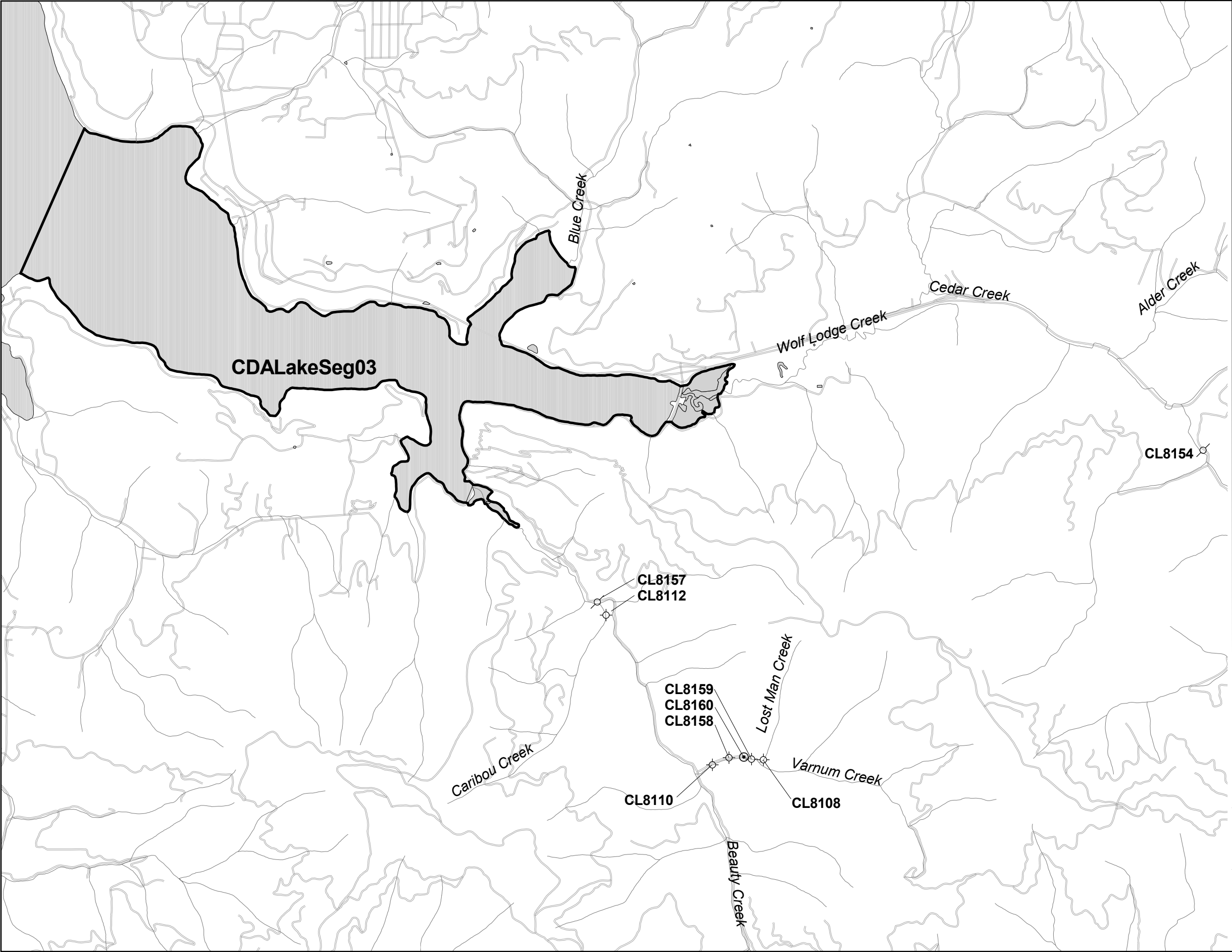
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RI Report

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LAYOUT: CDALakeSeg03 - Soil Sediment  
5/18/2000

This map is based on Idaho  
State Plane Coordinates West Zone,  
North American Datum 1983.  
Date of Plot: July 24, 2001



**Figure 4.1-5**  
**Coeur d' Alene Lake Segment CDALakeSeg03**  
**Surfacewater Sampling Locations**

**LEGEND**

- Seep Sampling Location
- Adit Sampling Location
- River Sampling Location
- Stream
- Road
- City
- CDALake Segment 3
- Lake/River/Floodplain

**Location Map**

**NOTES**

- Base map coverages obtained from the Coeur d'Alene Tribe, URS Greiner, Inc., CH2M HILL, and the Bureau of Land Management.
- Sampling locations obtained from URS Greiner, Inc. Technical Data Management database as of 03/29/00.

**SCALE 1: 40,000**

0 0.5 Miles

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Coeur d'Alene Basin RI/FS  
RI Report

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VIEW: CDALake Seg03 - Surface Water  
LAYOUT: CDALakeSeg03 - Surface Water  
5/18/2000

This map is based on Idaho State Plane Coordinates West Zone, North American Datum 1983.  
Date of Plot: May 18, 2000

## **5.0 FATE AND TRANSPORT**

The fate and transport of metals and nutrients in Coeur d'Alene Lake are discussed in this section. The discussion focuses on the following three central questions. One, what happens to metals and nutrients after they enter the lake? Two, what is the role of the lakebed sediments in regulation of metal and nutrient concentrations in the lake's water column? Three, what determines the amount of metals and nutrients discharged from the lake into the Spokane River?

The goal of this section is to answer these questions by examining the interaction of numerous physical, chemical, and biological processes as they relate to the fate and transport of metals and nutrients in Coeur d'Alene Lake.

- Section 5.1 - Retention of Metals and Nutrients
- Section 5.2 - Lake Hydrodynamics
- Section 5.3 - Sedimentation
- Section 5.4 - Geochemistry of Lakebed Sediments
- Section 5.5 - Lakebed Fluxes of Metals and Nutrients
- Section 5.6 - Mass Balances for Metals and Nutrients
- Section 5.7 - Lake Water Quality Status
- Section 5.8 - Eutrophication Potential
- Section 5.9 - Export of Metals and Nutrients from Coeur d'Alene Lake
- Section 5.10 - Summary of Fate and Transport in Coeur d'Alene Lake

These discussions used the conceptual model of fate and transport (Figure 5-1) as a template for evaluation of the numerous physical, chemical, and biological processes whose interaction affects the fate and transport of metals and nutrients in Coeur d'Alene Lake.

### **5.1 RETENTION OF METALS AND NUTRIENTS**

An important initial step in answering the question of what happens to metals and nutrients after they enter the lake is to quantify the residual between input and output loads of metals and nutrients. Fortunately, sufficient data for this initial step are available for much of the 1990s. A 1991-92 limnological study of Coeur d'Alene Lake quantified loads of metals and nutrients from numerous sources (Woods and Beckwith 1997). Loads for 1993 through 1997 were calculated for metals only using discharge and water-quality monitoring data collected by the USGS (Woods 1998). Loads for water year 1999 for metals and nutrients were developed from a water-

quality monitoring network study (Woods 2000a). Load calculation methods for the 1992-97 data were described by Woods and Beckwith (1997) and for the 1999 data by Woods (2000a). The residual load was calculated as the difference between inflow loads and the outflow load at the U.S. Geological Survey (USGS) gaging station 12419000, Spokane River, near Post Falls, Idaho.

The seven years represent a wide range in hydrologic conditions that affected Coeur d'Alene Lake. Annual mean discharges for the seven years ranged from 48 percent (1994) to 166 percent (1997) of the long-term mean annual discharge of 6,200 cubic feet per second (cfs) measured from 1914 through 1990 at the USGS gaging station Spokane River near Post Falls, Idaho (Kjelstrom, Stone, and Harenberg 1996).

The metal and nutrient loads developed for Coeur d'Alene Lake which are to be discussed in the following sections contain uncertainty because: 1) not all sources could be measured, and 2) all load calculations contain some degree of measurement error. For metal loads, the level of uncertainty attributable to unmeasured sources is small because the Coeur d'Alene River is by the far the dominant contributor of metals to the lake (Woods and Beckwith, 1997; Woods, 2000a). The uncertainty associated with unmeasured sources is higher for nutrients than metals because nutrient loads are contributed from virtually all parts of the lake's watershed, not just the Coeur d'Alene River. Measurement errors for loads are largely a combination of errors in measuring streamflow, sample collection and processing, and laboratory analyses. The magnitude of measurement errors for nutrient loads for the 1991-92 limnological study of Coeur d'Alene Lake (Woods and Beckwith, 1997) was evaluated using methods described by Brown (1987) and Winter (1981). For total phosphorus loads, error was about 10 percent of the annual inflow load in both years; whereas, error for total nitrogen loads for both years was about 11 percent of the annual inflow load. The error for metal loads was judged to be equal to or less than that for nutrient loads.

### **5.1.1 Metals**

#### ***5.1.1.1 Cadmium***

The inflow, outflow, and residual loads of whole-water recoverable (WWR) and dissolved cadmium are listed for the seven years in Table 5.1-1. Note that WWR loads represent the sum of dissolved and particulate loads. The magnitude of inflow and outflow loads of WWR and dissolved cadmium was positively correlated with the magnitude of discharge. Inflow loads of WWR cadmium ranged from 3,810 to 14,100 kilograms per year (kg/yr); dissolved cadmium loads ranged from 2,220 to 4,960 kg/yr. The median percentage of dissolved to WWR cadmium

for inflow loads was 56; the percentages ranged from 35 to 78. Outflow loads of WWR cadmium ranged from 1,690 to 5,830 kg/yr; dissolved cadmium loads ranged from 1,680 to 6,240 kg/yr. The median percentage of dissolved to WWR cadmium for outflow loads was 107; the percentages ranged from 76 to 107.

The retention of metals by Coeur d'Alene Lake was examined by dividing residual load by inflow load (Table 5.1-1). Approximately one-half of the inflow load of WWR cadmium was retained (median percent = 51) by the lake during the seven years. Retention of dissolved cadmium was much less (median percent = -3). The lake's retention of WWR loads of cadmium has not varied much over the seven years on the basis of the narrow range (46 to 59) in the percentage of residual load to inflow load. The lake's retention of dissolved cadmium over the seven years has been quite variable; the percentage of residual load to inflow load has ranged from -39 to 57.

The outflow loads of cadmium listed in Table 5.1-1 for 1992-97 were affected by the large number of concentrations reported as less than the analytical detection limit of 1 µg/L. Such concentrations were assigned a value of 0.5 µg/L for use in the load-calculation model. The assigned concentrations were as follows: WWR outflow load, 38 of 50 concentrations; dissolved outflow load, 16 of 21 concentrations. On the basis of reduced analytical detection limits employed for the 1999 water year sampling, the assigned concentrations of 0.5 µg/L were slightly high. During 1999, mean concentrations of WWR and dissolved cadmium measured for the lake outlet were 0.33 and 0.25 µg/L, respectively (Woods, 2000a). Therefore, outflow loads for 1992-97 were probably overestimated, possibly by a factor of 2.0 for dissolved loads and by a factor of 1.5 for WWR loads. The net effect of the overestimation would be to increase the residuals for WWR and dissolved loads; that is, more cadmium was retained by Coeur d'Alene Lake.

#### **5.1.1.2 Lead**

The inflow, outflow, and residual loads of WWR and dissolved lead are listed for the seven years in Table 5.1-1. The magnitude of inflow and outflow loads of WWR and dissolved lead was positively correlated with the magnitude of discharge. Inflow loads of WWR lead ranged from 62,900 to 1,840,000 kg/yr; dissolved lead loads ranged from 8,890 to 81,000 kg/yr. The median percentage of dissolved to WWR lead for inflow loads was 5; the percentages ranged from 4 to 14. Outflow loads of WWR lead ranged from 16,100 to 100,000 kg/yr; dissolved lead loads ranged from 2,640 to 13,700 kg/yr. The median percentage of dissolved to WWR lead for outflow loads was 16; the percentages ranged from 12 to 19.

The retention of metals by Coeur d'Alene Lake was examined dividing residual load by inflow load (Table 5.1-1). Approximately 90 percent of the inflow load of WWR lead was retained (median percent = 91) by the lake during the seven years. Retention of dissolved lead was slightly less; the median percentage was 71. The lake's retention of WWR loads of lead has not varied much over the seven years on the basis of the narrow range (72 to 96) in the percentage of residual load to inflow load. The lake's retention of dissolved lead over the seven years demonstrates an increasing trend in that the percentage of residual load to inflow load has steadily increased from 65 in 1992 to 85 in 1999.

The outflow loads of dissolved lead listed in Table 5.1-1 for 1992-97 were affected by the large number (13 of 21) concentrations reported as less than the analytical detection limit of 1 µg/L. Such concentrations were assigned a value of 0.5 µg/L for use in the load-calculation model. On the basis of reduced analytical detection limits employed for the 1999 water year sampling, the assigned concentration of 0.5 µg/L was slightly high. During 1999, the mean concentration of dissolved lead measured at the lake's outlet was 0.42 µg/L (Woods, 2000a). Therefore, outflow loads of dissolved lead were probably overestimated, but only by small percentage. The net effect of the overestimation would be to slightly increase the lake's retention of dissolved lead loads.

#### **5.1.1.3 Zinc**

The inflow, outflow, and residual loads of WWR and dissolved zinc are listed for the seven years in Table 5.1-1. The magnitude of inflow and outflow loads of WWR and dissolved zinc was positively correlated with the magnitude of discharge. Inflow loads of WWR zinc ranged from 458,000 to 1,860,000 kg/yr; dissolved zinc loads ranged from 453,000 to 996,000 kg/yr. The median percentage of dissolved to WWR zinc for inflow loads was 82; the percentages ranged from 54 to 100. Outflow loads of WWR zinc ranged from 263,000 to 890,000 kg/yr; dissolved zinc loads ranged from 225,000 to 767,000 kg/yr. The median percentage of dissolved to WWR zinc for outflow loads was 86; the percentages ranged from 49 to 98.

The retention of metals by Coeur d'Alene Lake was examined using the variable, residual load divided by inflow load (Table 5.1-1). Approximately one-third of the inflow load of WWR zinc was retained (median percent = 35) by the lake during the seven years. Retention of dissolved zinc was about the same, with a median percentage of 32. The ability of the lake to retain WWR loads of zinc has not varied much over the seven years on the basis of the narrow range (31 to 52) in the percentage of residual load to inflow load. The lake's retention of dissolved zinc over the seven years shows a decreasing trend in that the percentage of residual load to inflow load in 1992 was 43, but was 17 in 1997 and 1999.

## 5.1.2 Nutrients

### 5.1.2.1 Annual Loads

The purpose of this section is to quantify the absolute and relative magnitude of nutrient loads delivered to and exported by Coeur d'Alene Lake. Annual loads of total nitrogen and total phosphorus were reported for the lake for calendar years 1991-92 by Woods and Beckwith (1997) and for the 1999 water year by Woods (2000a); these results are summarized in Table 5.1-2.

The lake retained little of the total nitrogen it received during the three years; compared to inflow loads, the percentage of residual loads to inflow loads ranged from a -28 (1999) to 8 (1992). During 1991-92, the lake's two primary inflows, the Coeur d'Alene and St. Joe Rivers, delivered about 75 percent of the lake's inflow load of total nitrogen (Woods and Beckwith 1997). A similar calculation could not be done for the 1999 water year because many of the load sources to the lake were not quantified as they were in the 1991-92 study. The substantial decline in total nitrogen loads between 1991 and 1999 was unexpected in that the two years had similar discharges. The large difference is actually an artifact of changes in analytical detection and reporting limits at the USGS's water-quality laboratory. In the early 1990s, the laboratory's reporting limit for total ammonia plus organic nitrogen, a major component of total nitrogen, was 200 µg/L; concentrations less than that were reported as "less than." Total nitrogen concentrations used by Woods and Beckwith (1997) to compute 1991-92 loads used 200 µg/L for reported "less than" values. In the late 1990s, the laboratory's reporting limit was reduced to 100 µg/L; this accounts for a large portion of the difference between 1991 and 1999.

Contrasted with total nitrogen, the lake retained more of its inflow load of total phosphorus; the percentages of residual loads to inflow loads ranged from 26 (1999) to 59 (1991). The combined inflow loads from the Coeur d'Alene and St. Joe Rivers supplied 71 and 51 percent, respectively, of the lake's annual total phosphorus loads in 1991 and 1992 (Woods and Beckwith 1997). A similar calculation could not be done for the 1999 water year because many of the load sources to the lake were not quantified as they were in the 1991-92 study.

The seasonal variation in concentrations and loads of total phosphorus and total nitrogen at the lake's outlet was examined for the 1999 water year using graphical plots of daily concentrations and loads (Woods, 2000b). The period of low streamflow (July through November) contributed less than 10 percent of the annual loads of the two nutrients; conversely, the period of high streamflow (March through June) contributed about two-thirds of the annual loads of the two nutrients. Over the year, concentrations of total phosphorus had a narrow range, 10 to 13 µg/L.

Total nitrogen concentrations varied more over the year, ranging from 100 to 450  $\mu\text{g/L}$  and averaging about 150  $\mu\text{g/L}$ . Peak concentrations of total nitrogen occurred during a time of low streamflow (mid-August to mid-September) and likely resulted from phytoplanktonic conversion of dissolved inorganic nitrogen into particulate-bound organic nitrogen.

The next two sections focus on inorganic nitrogen and orthophosphorus because these were the two nutrients measured by the benthic flux study that will be discussed later in relation to the role of lakebed sediments. During 1991-92, inorganic nitrogen, measured as WWR, comprised about 33 percent of the total nitrogen load delivered to the lake by its two major inflow sources, whereas orthophosphorus, also measured as WWR, comprised about 20 percent of the total phosphorus load (Woods and Beckwith 1997). These values were similar in the 1999 water year; dissolved inorganic nitrogen was 38.5 percent of total nitrogen loads and dissolved orthophosphorus was 23.5 percent of total phosphorus loads (Woods 2000a).

#### ***5.1.2.2 Inorganic Nitrogen***

Inorganic nitrogen represents the sum of ammonia, nitrate, and nitrite. Loads of inorganic nitrogen for 1991-92 were calculated on the basis of WWR concentrations; in the 1999 water year, they were based on dissolved concentrations. The use of WWR and dissolved concentrations among the three years did not introduce a bias because their percentage contributions to total nitrogen were within about 5 percent.

The inflow loads of inorganic nitrogen, presented in Table 5.1-2, ranged from 146,000 kg/yr (1992) to 333,000 kg/yr (1991); outflow loads ranged from 184,000 kg/yr (1992) to 391,000 kg/yr (1991). The residual load of inorganic nitrogen in each of the three years was negative because outflow loads exceeded inflow loads. The percentages of residual loads to inflow loads ranged from -17 (1991) to -32 (1999).

#### ***5.1.2.3 Orthophosphorus***

As with inorganic nitrogen, loads of orthophosphorus for 1991-92 were calculated on the basis of WWR concentrations; in the 1999 water year, they were based on dissolved concentrations. The use of WWR and dissolved concentrations among the three years did not introduce a bias because their percentage contributions to total phosphorus were within about 4 percent.

Inflow loads of orthophosphorus, presented in Table 5.1-2, ranged from 11,100 kg/yr in 1992 to 24,000 kg/yr in 1991; outflow loads ranged from 11,000 kg/yr (1992) to 16,800 kg/yr (1999).

The residual loads of orthophosphorus for the three years ranged from -500 to 10,000 kg/yr. The percentages of residual loads to inflow loads ranged from -3 (1999) to 42 (1991).

## **5.2 LAKE HYDRODYNAMICS**

### **5.2.1 Hydrologic Budget**

The volume of water entering and exiting Coeur d'Alene Lake (its hydrologic budget), is an important determinant of the quantity of constituents delivered into and discharged from the lake. The hydrologic budget provides an accounting of the gains and losses of water associated with sources such as surface-water inflow and outflow, precipitation and evaporation, groundwater inflow and outflow, wastewater-treatment facility inflows, industrial and municipal withdrawals, and changes in lake storage. The fate and transport of these constituents within the lake help regulate water-quality characteristics such as light penetration, dissolved-oxygen concentrations, nutrient and metals concentrations, and biological production.

The limnological study of Coeur d'Alene Lake quantified hydrologic budgets for calendar years 1991 and 1992 (Woods and Beckwith 1997). Numerous budget components were quantified for both years, either by measurement or estimation. Both budgets were considered accurate in that the residual of outflows minus inflows was less than the overall error of measured and estimated budget components. Overall error was about 12 percent of total inflow. The hydrologic budgets indicated that the combined inflow from the Coeur d'Alene and St. Joe Rivers during 1991 and 1992 accounted for 93.2 and 92.1 percent, respectively, of all inflows to the lake. The St. Joe River was the larger inflow source, delivering about 28 percent more inflow than the Coeur d'Alene River. At least 90 percent of the outflow was via the Spokane River in both years.

### **5.2.2 Hydraulic-Residence Time**

The ratio of inflow volume or outflow volume to lake volume has been used to calculate the time it would theoretically take to fill or empty a lake. When inflow volume is used in the calculation the result is commonly termed retention time (lake volume divided by inflow volume) whereas hydraulic-residence time is obtained when outflow volume is the divisor. On an annual basis, the two values often are comparable. Hydraulic-residence time was chosen for the following discussion because the outflow volume of Coeur d'Alene Lake is available for many years, whereas the inflow volume from numerous sources has only been quantified in 1991-92 during the limnological study reported by Woods and Beckwith (1997). The outflow volume is measured at USGS gaging station 12419000, Spokane River near Post Falls, Idaho which has a

period of record dating back to October, 1912. The volume of Coeur d'Alene Lake at its normal summer pool elevation of 648.7 meters (m) above NGVD (National Geodetic Vertical Datum of 1929) is 2.8 billion m<sup>3</sup> (Woods and Berenbrock 1994).

Hydraulic-residence time for the lake has averaged 0.51 years for the period 1913-1999 (Table 5.2-1). Theoretically, 186 days would be needed to empty Coeur d'Alene Lake in the absence of any inflow. During the 1991-92 limnological study, the higher than normal inflow volume of 1991 yielded a shorter hydraulic-residence time (0.45 years), whereas the below-average inflow volume of 1992 almost doubled it. Water year 1999 had an hydraulic-residence time of 0.42 years. Inflow and outflow discharges vary widely during a year in response to climatological conditions within the contributing drainage basin. The minimum and maximum monthly outflow discharges for the four time periods in Table 5.2-1 were divided into lake volume to illustrate the wide differences in hydraulic-residence time during those years. On average, August has been the month of minimum discharge whereas May was the month with maximum discharges (Brennan et al. 2000). For the period of record, hydraulic-residence times have ranged from 3.3 years for minimum monthly discharge to 0.18 years for maximum monthly discharge. Calendar year 1991 and water year 1999 had values similar to the long-term average. The very low discharges recorded for August 1992 resulted in an hydraulic-residence time of 5.2 years.

Although hydraulic-residence time is a theoretical concept, the processes which it incorporates are important for understanding fate and transport in Coeur d'Alene Lake. The rate at which water enters and leaves the lake affects the amount of turbulence within the water column, both in the horizontal and vertical dimensions. In years of above-normal discharge, water-column turbulence and the advective transport of particulate materials delivered by riverine inflow are increased. Conversely, low-discharge years are more likely to develop stronger thermal stratification and are less likely to flush particulate materials from the lake.

### **5.2.3 Inflow-Plume Routing Within the Lake**

The previous discussion of hydraulic-residence and retention times provided insight into the relation of outflow or inflow magnitude on the generation of turbulence and advective transport within the lake. However, their basis is theoretical and is more suited to comparisons among lakes representing wide ranges of hydraulic-residence and retention times. In actuality, the movement of riverine inflows within a lake can be quite complex because of temporal and spatial differences in density between riverine and lake water. Three generalized cases of inflow-plume routing were discussed by Fischer et al. (1979): overflow, interflow, and underflow. Overflow occurs if the inflow plume is warmer (less dense) than the lake; river water floats on the lake's

surface. Interflow occurs at the lake depth where the temperature, or density, of the inflow plume and lake are nearly equal. If the inflow plume is at or near the temperature of the lake's near-bottom water (hypolimnion), then underflow occurs. Turbulence at the interface of the inflow plume and the lake mixes the two water masses until thermal equilibrium is reached. The spatial extent of inflow plume routing is highly dependent on the magnitude of riverine discharge. Riverine discharges generated by snowmelt-runoff and flood events can penetrate farther into the receiving lake because these events carry larger volumes which increase turbulence and advective transport.

The fate and transport of metals and nutrients in Coeur d'Alene Lake is highly dependent upon inflow-plume routing of the lake's two primary inflow sources, the Coeur d'Alene and St. Joe Rivers. The routing of the Coeur d'Alene River into the lake is particularly important for metals, in that the majority of the lake's metal loads emanate from this river (Woods and Beckwith 1997; Woods 2000a).

An evaluation of inflow plume routing (Table 5.2-2) was done using water-temperature data for the two rivers and the lake from the 1991-92 limnological study (Woods and Beckwith 1997). Water year 1999 was also evaluated using data from Woods (2000c) and Brennan et al. (2000); however, lake water-column sampling was only conducted between June and October, instead of year-round. The evaluation relied upon comparisons of the relative differences in river temperature versus the vertical distribution of lake water temperatures at the lake's deepest station, C4 near Driftwood Point (Figure 5.2.3-1). In cases where river temperature had not been measured coincident with lake temperature profiles, the lake's temperature structure was estimated on the basis of water temperature profiles measured before and after the measured river temperature. This estimation was aided by published isopleth diagrams of lake temperature at station C4, which were measured during the 1991-92 limnological study (Woods and Beckwith, 1997). The potential effects of suspended-sediment concentrations on the density of the inflow plumes could not be evaluated due to a paucity of relevant data.

The 44 comparisons of inflow and lake temperatures in Table 5.2-2 indicate that overflow was the most common mode of inflow plume routing, occurring in about 60 percent of the comparisons. Interflow or underflow each occurred in about 20 percent of the comparisons. Overflow was present in all months except October, November, and December. During those three months, underflow was the most likely mode of inflow plume routing. Interflow tended to occur during the spring or autumn months when the lake was most likely to be transitioning into or out of water-column thermal stratification. Instantaneous discharges are also listed in Table 5.2-2 because the volume of inflow affects the spatial extent of inflow-plume routing. At small inflow discharges, the inflow plume's influence on the lake is muted by the rapid mixing

and equilibration of riverine and lake temperatures. Underflows tended to be associated only with small inflow discharges, thereby reducing the likelihood that lakebed sediments would be eroded and resuspended by riverine inflows into the lake. The timing of underflows is reasonable in that during October through December the Coeur d'Alene and St. Joe Rivers are cooling more rapidly than Coeur d'Alene Lake with its much larger heat capacity. Overflows occurred over a wide range of inflow discharges because both the Coeur d'Alene and St. Joe Rivers have lengthy backwater-affected reaches that cause heating of inflow water via solar radiation.

The extent of inflow-plume routing into Coeur d'Alene Lake during the 1990s was evaluated with anecdotal information and several published data sets. A powerful storm during February 1996 dropped several inches of rain on a heavy mountain snowpack and created severe flooding in northern Idaho river basins, including the Coeur d'Alene and St. Joe River basins. This storm delivered a large volume of sediment to Coeur d'Alene Lake and produced visible turbidity throughout the lake for several months (Idaho Division of Environmental Quality 2000). The magnitude of the February 1996 flood peaks at four long-term USGS gaging stations in the two basins was within about 10 percent of the 100-year flood peak on the basis of data reported by Beckwith, Berenbrock, and Backsen (1996). Suspended-sediment concentration in the Coeur d'Alene River at Harrison (USGS station 12413860) was 620 milligrams per liter (mg/L) on February 10, 1996 (Beckwith 1996). By way of comparison, median and range in suspended-sediment concentrations of 10 samples collected during the 1999 water year (Horowitz 1999) were, respectively, the 3.2 mg/L and 0.8 (September 9) to 56 mg/L (May 27).

The effect of the turbid inflow plume was evident downstream of Coeur d'Alene Lake. Suspended-sediment concentration measured at the Spokane River near Post Falls on March 8, 1996 was 80 mg/L (Brennan et al. 1997). Inflow-plume routing into the lake was also evaluated using data collected during the snowmelt-runoff event of water year 1997. Water-temperature profiles and water-column transparency (measured by secchi disc) reported by the Idaho Division of Environmental Quality (IDEQ 2000) indicated the movement of the inflow plume into and through Coeur d'Alene Lake during May and June 1997. The temperature of the inflow plume on June 6, 1997 was 11 degrees Celsius (°C), as measured at Coeur d'Alene River near Harrison (Brennan 1998). Water-column temperature profiles collected on May 28 at four lake stations (Harvey 2000) indicated the inflow plume was a combination of overflow and interflow within the upper 10 m of the water column. Secchi-disc readings from the central and northern lake stations were, respectively, 1.1 and 2.0 m on May 28. By comparison, annual mean secchi-disc readings for the four stations ranged from 8 to 9 m during 1995 through 1999 (IDEQ 2000).

The water-quality data available from these high-volume discharge events of 1996 and 1997 revealed that riverine inflows were routed into the lake primarily as overflows and that part of the inflow plume passed through the lake; however, these were considered to be rare hydrologic events in which the lake acted as a conduit for the transport of metals from the Coeur d'Alene River to the Spokane River. This conceptual model was invalidated by the results of a limnological study of inflow-plume routing conducted during the 1999 snowmelt-runoff event.

The discharge and chemical nature of the Coeur d'Alene and St. Joe River plumes into and through Coeur d'Alene Lake were tracked with specialized water-quality instrumentation and sampling during the snowmelt-runoff event of May and June, 1999 (Woods 2000c). The study sought to answer two questions: 1) can the riverine inflows and their associated chemical nature be clearly identified within the lake; and 2) do sediments, nutrients, and metals carried by the riverine inflows travel far enough in the lake to be discharged to the Spokane River? The USGS collected data during June 2 and 3, 1999 at the following eight stations on Coeur d'Alene Lake: five lake stations, one each near Conkling Point (L.5), University Point (L.4), Driftwood Point (L.3), Tubbs Hill (L.1), and Wolf Lodge Bay (L.2); two stations at the mouths of the Coeur d'Alene (L.CR) and St. Joe (L.SJR) Rivers; and the lake's outlet into the Spokane River (L.SR) (Figure 5.2-1). The study results, presented in Tables 5.2-3 to 5.2-5, clearly identified the riverine inflows as a combination of overflow and interflow within the upper 5 to 13 m of the lake, from station L.4 and northward to the lake's outlet. South of station L.4, the lake is shallow enough to allow full-depth mixing of the two riverine inflows. Only marginal influence from riverine inflows was measured in Wolf Lodge Bay, which is somewhat isolated from the northward flow of the two rivers.

The most notable differences between the riverine inflows and lake water were for light transmission, conductivity, and concentrations of lead, zinc, and nitrogen. Riverine lead concentrations were higher than those of lake water, whereas riverine light transmission, conductivity, and concentrations of zinc and nitrogen were lower than those of lake water. The chemical nature of water discharged into the Spokane River was more closely related to riverine inflows than lake water. The inflow plume of the Coeur d'Alene River traversed Coeur d'Alene Lake in about 6 days on the basis of discharge and constituent concentration data collected at two USGS gaging stations, Coeur d'Alene River near Harrison and Spokane River near Post Falls (Woods 2000a). At the Harrison station, maximum values for discharge and total lead concentrations and minimum concentrations for dissolved cadmium and zinc all occurred on about May 27. Similar maximum and minimum values were measured at the Post Falls station on about June 1. The transport of sediment, nutrients, and metals through Coeur d'Alene Lake and into the Spokane River was measured during a spring snowmelt runoff event that had a probability of occurring every other year, on the basis of long-term streamflow records for the

Coeur d'Alene River. Such transport is, therefore, not unusual for Coeur d'Alene Lake and the Spokane River during periods of snowmelt runoff or high discharges created by rain-on-snow events.

#### **5.2.4 Thermal Stratification and Convective Overturn**

The physical limnological processes of thermal stratification and convective overturn are strongly correlated with the vertical distribution of water-quality properties and constituents. The thermal structure of some lakes, such as Coeur d'Alene Lake, may be established, in part, by riverine inflows routed as overflow. However, the major source of heat for most lakes is the solar radiation that impinges upon the lake's surface (Wetzel 1975). Wind energy distributes the surface heating deeper into the water column until density differences impede deeper mixing. In lakes deep enough to resist full-depth mixing, solar heating and wind mixing during the summer vertically segregate the water column into three zones: an epilimnion, metalimnion, and hypolimnion.

The upper zone, the epilimnion, is the site of most of the lake's biological production because light inputs are sufficient to drive photosynthetic production by phytoplankton. The metalimnion is the zone of maximum temperature change. Density differences may be sufficient to impede settling of detrital material into the lower zone, the hypolimnion. A thermocline is present within the metalimnion if the rate of temperature change exceeds 1 C per meter. The hypolimnion overlies the lakebed sediments and typically has more thermal stability than the epilimnion or metalimnion. During thermal stratification, the hypolimnion is isolated from atmospheric exchange and thus may develop a hypolimnetic dissolved-oxygen deficit if biological and chemical oxygen demands exceed the oxygen mass available at the onset of thermal stratification. During the spring and autumn months, solar radiation input is less than in the summer. Windy conditions are also more prevalent during the spring and autumn months. This combination facilitates convective overturn in which the water column has weak thermal stratification which allows full-depth mixing. A lake is termed dimictic if it experiences convective turnover in the spring and autumn. Such mixing is an important mechanism for the vertical movement of water-quality constituents such as dissolved oxygen, nutrients, and metals.

Coeur d'Alene Lake was dimictic during the 1991-92 limnological study, on the basis of isopleth diagrams of temperature reported by Woods and Beckwith (1997). The lake developed a thermocline in mid-July of 1991 and in mid-June of 1992; the thermoclines were lost by early October. The maximum depth of the thermocline was 16.5 m in 1991 and 21.5 m in 1992. Maximum thermocline depths measured by IDEQ monitoring of the lake during 1995-99 have ranged from 15 to 24 m (Harvey 2000). Over the seven years (1991-92, 1995-99) in which the

lake's thermal structure has been measured, the epilimnion depth has averaged about 10 m during July through September. This represents about 38 percent of the lake's total volume. The upper depth of the hypolimnion over the same period has averaged 15 m; thus, the hypolimnion accounted for about 50 percent of the total lake volume. The remaining 12 percent of lake volume constituted the metalimnion during July through September.

## **5.3 SEDIMENTATION**

### **5.3.1 Sedimentation Rates**

Several of the preceding sections discussed lake hydrodynamics as they affect the fate and transport of metals and nutrients within Coeur d'Alene Lake. Hydrodynamics often affect fate and transport of sediment particles via geochemical mechanisms such as adsorption and complexation. For example, the majority of lead, nitrogen, and phosphorus input to and discharged from Coeur d'Alene Lake during water year 1999 was in the particulate, not dissolved, fraction (Woods 2000a). Even the dissolved fraction has some association with colloidal-sized particles because the pore size of 0.45  $\mu\text{m}$  used to obtain dissolved samples allows the passage of colloidal-bound constituents. Sediment-associated constituents may settle to the lakebed if their mass is large enough to overcome turbulence within the water column. If turbulence can keep the particles entrained, then advective transport may transport sediment-associated constituents increasing distances from their source, perhaps as far as the lake's outlet.

An empirical method sometimes used for calculation of sedimentation rates is Stokes' Law which describes the rate at which a particle falls through a water column (Hakanson and Jansson 1983). The equation is based on a spherical particle falling through calm water; therefore, the effects of turbulence are ignored. Quantification of sedimentation rates in a lake with a short hydraulic-residence time, such as Coeur d'Alene Lake, is too complex for the application of Stokes' Law. In the absence of well-developed estimates of the sediment flux for the lake and water-column sedimentation rates derived from moored, in-lake sediment traps, the results of lakebed sediment studies were used to estimate sedimentation rates for Coeur d'Alene Lake.

The 1991-92 limnological study of Coeur d'Alene Lake included collection and analysis of 12 gravity cores of lakebed sediments from throughout the lake. Those results were reported by Horowitz and others (1995). The thickness of the banded zone in each core and the thickness of sediment overlying the Mt. St. Helens ash layer are listed in Table 5.3-1. Calculated sedimentation rates for the banded zones are based on 80 years of deposition, from 1910-90. That time interval was used because the cores were collected in 1990 and Horowitz et al. (1995)

used age-dating techniques to determine that 1910 was the approximate year when layering of the cores commenced.

The overall trend was for sedimentation rates in Coeur d'Alene Lake to decrease with increased distance from the mouth of the Coeur d'Alene River; the smallest sedimentation rate was measured for core 13 in the central portion of the lake's northern end.

The 10-year time interval for the sedimentation rates above the ash layer from 1980 eruption of Mt. St. Helens was evaluated. Sedimentation rates of the banded zones ranged from 0.21 to 1.5 centimeters (cm) per year, whereas sedimentation rates above the ash layer ranged from 0.03 to 2.0 cm per year. Banded zones were lacking in core 7, taken in the Coeur d'Alene River delta. Horowitz et al. (1995) reported that core 7 exhibited cross-bedded layers and contained coarser particles than the other cores. They inferred the delta was a high-energy area because of its shallow depth and close proximity, 0.3 kilometers (km), to the mouth of the Coeur d'Alene River. The contrast between core 7 and core 123, taken about 1.8 km west of the mouth of the Coeur d'Alene River, was important because core 123 had the highest sedimentation rate of the 12 cores. One might initially infer that erosion of the up-lake deltaic deposits could account for the high sedimentation rate; however, core 123 was banded for 119 cm of its overall length of 126 cm and thus represented a depositional area. The overall trend was for sedimentation rates in Coeur d'Alene Lake to decrease with increased distance from the mouth of the Coeur d'Alene River; the smallest sedimentation rate was measured for core 13 in the central portion of the lake's northern end.

### **5.3.2 Metals**

The evaluation of sedimentation of metals in Coeur d'Alene Lake was developed using the geochemical data reported by Horowitz, Elrick, and Cook (1993) and Horowitz et al. (1995) for about 150 surficial lakebed sediment samples and the 12 lakebed cores discussed in the preceding section. The surficial samples were collected in August 1989, at a density of one per square kilometer (km<sup>2</sup>), using a stainless-steel Ekman dredge. The surficial samples represent the upper 2 cm of the lakebed. Surficial and core samples were subjected to the same analytical methods which are described in detail in Horowitz, Elrick, and Cook (1993) and Horowitz et al. (1995).

Horowitz et al. (1995) concluded that the surficial and subsurface sediments over about 85 percent of the lakebed's surface area were highly enriched in antimony, arsenic, cadmium, copper, lead, mercury, silver, and zinc. The metals-enriched sediments extended northward from about Conkling Point and varied in thickness from 17 to 119 cm. The thickest layer and some of

the highest concentrations were near the mouth of the Coeur d'Alene River. Other high concentrations were measured in the lake's northern end and reflected advective transport of fine-grained sediments. The sediments were typically very fine-grained; mean grain size was much less than 63  $\mu\text{m}$ .

The mass of metals-enriched sediments in the lake was calculated by Horowitz et al. (1995) using the core data and lake bathymetry data. They concluded that about 75,000,000 tons of metals-rich sediments blanket the lakebed. If evenly distributed over the lakebed surface area, the enriched sediments would represent a layer about 35 cm thick. If one uses 1910 as the date of onset of sedimentation of metals-enriched sediments, then the average lakewide sedimentation rate is 0.44 cm per year. Masses of selected metals were also calculated and compared to the masses that would be in place if background concentrations had been deposited. The background median concentrations of selected metals were based on 189 core-sample aliquots taken from beneath metal-enriched zones in cores from Coeur d'Alene Lake. The background masses for the majority of metals typically represented less than 2 percent of the enriched masses. The enriched and background masses for cadmium, lead, and zinc are listed in Table 5.3-2. For cadmium, 99.4 percent of the total mass was attributable to enrichment. For lead, the percentage was 99.6 and for zinc, it was 95.8.

### 5.3.3 Nutrients

The evaluation of sedimentation rates for nutrients was based on the 20 lakebed samples collected in Coeur d'Alene Lake in June 1992 and reported by Woods and Beckwith (1997). The samples were collected using a stainless-steel Ponar dredge which sampled the upper 15 cm of the lakebed. Concentrations of total phosphorus and total nitrogen for the 20 stations are listed in Table 5.3-3. Total phosphorus concentrations ranged from 500 to 1,600 milligrams per kilogram (mg/kg); the mean was 940 mg/kg. By comparison, the mean phosphorus concentration reported for soil and rock in the study area by the National Uranium Resource Evaluation Program is 500 mg/kg (Smith 1994). For total nitrogen, concentrations ranged from 860 to 3,900 mg/kg; the mean was 2,100 mg/kg. The smallest concentration of total phosphorus (500 mg/kg) was measured at the mid-lake station near Blue Point where the lakebed is subject to erosion due to its shallowness and close proximity to the mouth of the St. Joe River. The largest total phosphorus concentration (1,600 mg/kg) was measured at the mid-lake station near Tubbs Hill, in the deep northern end of the lake, where deposition predominates. Analogous to total phosphorus, the smallest concentration of total nitrogen (1,100 mg/kg) among the mid-lake stations was measured near Blue Lake, whereas the largest concentration (2,900 mg/kg) was measured in the lake's northern end. Lakewide, the smallest and largest concentrations of total nitrogen were measured in Rockford and Windy Bays, respectively.

## 5.4 GEOCHEMISTRY OF LAKEBED SEDIMENTS

There is little doubt that the lakebed sediments of Coeur d'Alene Lake are highly enriched in metals and that the source of these metals is the long-term mining and ore-processing activities within the Coeur d'Alene River Basin. As early as 1911-12 it was noted by Kemmerer et al. (1923) that the silt load of the Coeur d'Alene River had increased commensurately with mining operations and that a noticeable plume could be observed far into Coeur d'Alene Lake. A series of studies reported by Funk et al. (1975) noted increased metal concentrations in lakebed sediments from the mouth of the Coeur d'Alene River to the lake's outlet; the thickness of the deposits ranged from 80 to 5 cm and decreased with proximity to the lake's outlet. Sediment samples collected by the EPA in the mid-1980s noted substantially increased metal concentrations in Coeur d'Alene Lake (Hornig, Terpening, and Bogue 1988). None of the Coeur d'Alene Lake studies done prior to the late 1980s addressed the geochemistry, other than concentration, of the lakebed sediments.

During the summers of 1989 and 1990, the USGS collected about 150 surficial samples and 12 gravity cores of lakebed sediments in Coeur d'Alene Lake in order to determine concentration, partitioning, and potential environmental availability of selected metals (Horowitz, Elrick, and Cook 1993; Horowitz et al. 1995). These samples verified the earlier-reported conclusions regarding concentration; that is, lakebed sediments for about 85 percent of the lake are substantially enriched in Ag, As, Cu, Cd, Hg, Pb, Sb, and Zn and are typically very fine-grained (mean grain sizes  $\ll 63 \mu\text{m}$ ). An important conclusion derived from chemical analyses of separated heavy and light mineral fractions and a two-step sequential extraction procedure was that most of the enriched metal concentrations are associated with an operationally defined (by partial chemical extraction) Fe oxide phase; much smaller percentages are associated with organics/sulfide or refractory phases also operationally defined by partial chemical extraction. The significance of the metal's association with Fe oxides was enhanced because a concurrent limnological study of the lake (Woods and Beckwith 1997) investigated the potential for releases of metals and nutrients from the lakebed sediments into the overlying water column in response to eutrophication effects on the hypolimnetic dissolved-oxygen deficit of the lake. The Fe-oxide-associated metals would be subject to dissolution and release from the lakebed sediments if reducing conditions were produced within the hypolimnion as a consequence of eutrophication. Previously, the metals in the surficial lakebed sediments were thought to be associated with sulfides and, under reducing conditions, would remain immobile.

Ongoing litigation over the link between mining industry practices and the presence of highly elevated metal concentrations in the lakebed of Coeur d'Alene Lake has brought close scrutiny of the limnological and lakebed sediment studies of the lake. Pedersen (1996) and Pedersen and

Carmack (1999) took issue with the conclusions of Horowitz, Elrick, and Cook (1993) regarding the association of metals with Fe oxides. Pedersen and Carmack asserted that Horowitz and colleagues used a poor sampling approach and an improper analytical scheme that yielded unacceptable data for concluding that metals are associated with Fe oxides, not sulfide. Pedersen and Carmack cited a study by Harrington et al. (1998) who showed that lead and zinc in the surface sediments of Coeur d'Alene Lake are primarily hosted by sulfide mineral phases and secondarily by organic matter. Pedersen and Carmack concluded from Horowitz's and Harrington's research that the lakebed sediments are anoxic at very shallow depths and therefore will be environmentally stable because of their association with sulfides, not Fe oxides.

The procedural differences between the studies associating metals with Fe oxides or sulfides in Coeur d'Alene Lake were reviewed by Mavis (1999) in an attempt to clarify this important issue. Mavis concluded that the technical differences between the studies of Horowitz, Elrick, and Cook (1993) and Harrington et al. (1998) were smaller than perceived. Horowitz's sequential extractions were performed with surficial-sediment samples taken from the upper 2 cm of the lakebed; Harrington's sequential extractions were performed on 8-cm gravity core sections. Harrington's samples were an admixture of oxic, suboxic, and anoxic sediment materials because the depth of the oxic/anoxic boundary in Coeur d'Alene Lake sediments is reported to be between 2 to 6 cm (Harrington et al. 1998) or 1 to 5 cm (Balistrieri 1998) below the sediment/water interface. Harrington's samples were obtained primarily in or near the deltaic deposits of the Coeur d'Alene River; Horowitz's samples were obtained throughout the lake. Both research groups employed sequential extraction methods that differed somewhat from the original method of Tessier, Campbell, and Bisson (1979), which they both cited. Harrington noted evidence of upward migration of metals in their core samples. This observation conforms with water-quality data reported for the summer of 1999 by the USGS (Brennan et al. 2000); concentrations of dissolved cadmium, lead, and zinc in the hypolimnion of Coeur d'Alene Lake were between 1.5 and 3 times higher than those measured in the upper water column. Horowitz's research showed that surficial sediments were oxidized, on the basis of direct inspection and sequential extraction test results. A similar result can be inferred from Harrington's research on the basis of phosphate and arsenic enrichment in surface or near-surface core sections. Pedersen also agreed, after further review of the studies, that surficial sediments were oxidized with the thickness ranging from 0 to 5 cm (Pedersen 2000).

## **5.5 LAKEBED FLUXES OF METALS AND NUTRIENTS**

### **5.5.1 Definitions and Approaches**

Benthic fluxes define the physical transport of dissolved metals and nutrients across the sediment-water interface. This transport is a function of the concentrations in the overlying water and in the porewater just below the interface (the chemical gradient) and the molecular or eddy diffusion coefficients for the elements of interest. Benthic fluxes have both direction and magnitude. The direction indicates whether the sediment supplies (acts as a source) or removes (acts as a sink) dissolved metals and nutrients to or from the overlying water. Sediments act as a source when dissolved metal and nutrient concentrations in the porewater are greater than in the overlying water (positive flux) or a sink when dissolved metal and nutrient concentrations in the overlying water are greater than in the porewater (negative flux). The magnitude of benthic fluxes depends on the steepness of the chemical gradient and the mode of physical transport, and can be used to determine the relative importance of sediments as a source or sink for dissolved metals and nutrients in the lake.

Two major studies have examined benthic fluxes of dissolved metals and nutrients in Coeur d'Alene Lake (Balistrieri 1998; Kuwabara et al. 2000). Between the two studies, three different methods were used to determine benthic fluxes at seven different locations within the lake.

The study discussed by Balistrieri (1998) used concentrations of metals in water overlying the sediments and in porewater to calculate benthic fluxes using Fick's First Law. Porewater was collected using diffusion-controlled equilibrator samplers, also known as peepers or dialyzers, and by centrifuging water from sediment sections taken from cores. The calculations assumed that benthic fluxes were controlled by molecular diffusion across the sediment-water interface. Balistrieri (1998) noted that oxidation of the porewater samples likely occurred during collection and handling of the samples. This oxidation probably affected the concentrations of certain metals in the porewater (iron, and metals that adsorb to the iron-oxide phases), and thereby, influenced the benthic flux calculations. Despite this concern, benthic fluxes were calculated using this method for the following five locations within the lake (Figure 5.3.2-1): one northern station (Valhalla), three mid-lake stations (East Point, Delta, and Harlow Point), and one southern station (Chatcolet).

The study of Coeur d'Alene Lake discussed by Kuwabara et al. (2000) used an in-situ benthic flux chamber that isolated a volume of water overlying the sediment and sampled it as a function of time. Fluxes were calculated from changes in the concentrations of constituents during the deployment time. In addition, core-incubation experiments were performed in a laboratory on

cores collected in the lake at the sites of the benthic-flux chamber deployments. In order to bracket dissolved-oxygen concentrations in the lake, the overlying water in the cores was replaced with aerated or argon-purged water and was then sampled as a function of time. Fluxes were calculated from changes in dissolved-element concentrations as a function of time. No assumption about the mechanism of transport (molecular or eddy diffusion) is needed to determine fluxes using these two methods. Kuwabara et al. (2000) noted that differences between fluxes determined from the benthic flux chamber and the core incubations suggest that bubbling of the overlying water during the core-incubation experiments may have re-suspended lakebed sediment particles and significantly altered chemical gradients and, thereby, fluxes across the water-sediment interface in the incubated cores. Benthic fluxes in the Kuwabara study were determined using both methods described above at two locations; a main-channel station about 7 km downstream of the mouth of the Coeur d'Alene River and a station within Mica Bay (Figure 5.2.3-1).

A summary of the methods used to determine benthic fluxes and the elements (chemical species) whose fluxes were calculated from each method is listed in Table 5.5-1. Although benthic fluxes for several metals were determined by all methods, there are many metals whose benthic fluxes were determined by only one or two methods.

## **5.5.2 Direction and Magnitude of Benthic Fluxes**

### ***5.5.2.1 Dissolved Metals and Sulfate***

The results of benthic-flux measurements from the three methods are summarized in Table 5.5-2 for cadmium, copper, iron, mercury, methyl mercury, manganese, lead, zinc, and sulfate. Each value is reported as micrograms per square centimeter of lakebed surface per year ( $\mu\text{g cm}^{-2} \text{ yr}^{-1}$ ). A negative sign indicates the constituent moved downward into the lakebed sediments.

The primary purpose of Table 5.5-2 is to summarize the wide range of directions and magnitudes of benthic fluxes measured by the three methods. The in-situ benthic-flux chamber method is considered to be the most representative of conditions in Coeur d'Alene Lake, because this method trapped an existing parcel of lakebed sediment, associated pore-water, and overlying lake water and measured benthic flux without major alteration of pre-existing conditions. The incubation of aerated and argon-purged cores was designed to assess benthic flux over a wide range of dissolved-oxygen concentrations; however, as discussed by Kuwabara et al. (2000), the bubbling and consequent resuspension of fine particulate matter likely altered the chemical gradient between porewater and overlying water. As discussed by Balistrieri (1998), oxidation of the porewater samples collected and processed at the stations at Valhalla, East Point, Harlow

Point, Delta, and Chatcolet likely altered some metal concentrations in the porewater and affected calculation of benthic flux. In summary, the values listed in Table 5.5-2 should not be averaged because the three methods were not designed to produce replicate measurements of benthic flux.

On the basis of the in-situ flux-chamber results listed in Table 5.5-2, the following dissolved metals showed a positive flux out of the lakebed sediments of Coeur d'Alene Lake: cadmium, copper, iron, manganese, lead, and zinc. The smallest flux was for copper,  $1.1 \mu\text{g cm}^{-2} \text{ yr}^{-1}$ ; the largest was for manganese,  $3,700 \mu\text{g cm}^{-2} \text{ yr}^{-1}$ . Note that the positive fluxes represent the net result of dissolved constituents moving from the lakebed into the overlying water column minus some portion of that benthic flux that may have geochemically reacted with constituents such as iron and manganese and then reprecipitated back to the lakebed.

#### **5.5.2.2 Dissolved Nutrients and Organic Carbon**

The benthic flux of dissolved nutrients and dissolved organic carbon (Table 5.5-3) were measured by two of the three methods listed in Table 5.5-1. As noted in the previous section, the results from the in-situ benthic-flux chamber method were deemed most representative of conditions in Coeur d'Alene Lake. The benthic fluxes for orthophosphorus, nitrite plus nitrate, ammonia, the sum of nitrate plus nitrate and ammonia (dissolved inorganic nitrogen), and dissolved organic carbon were all positive, indicating movement out of the lakebed sediments.

#### **5.5.3 Molecular Versus Eddy Diffusion**

Determination of benthic fluxes using Fick's First Law assumes that ions are transported by molecular diffusion. This assumption may be incorrect if the activities of benthic organisms enhance transport of ions across the sediment-water interface via eddy diffusion. Bio-irrigation generally results in larger benthic fluxes of dissolved elements than determined by Fick's First Law. However, there are several lines of evidence suggesting that molecular diffusion is the dominant transport mechanism for ions across the sediment-water interface in Coeur d'Alene Lake (Kuwabara et al. 2000).

First, the abundance of macroinvertebrates at the two benthic-flux chamber deployment stations was very low. There were an insufficient number of organisms to cause significant bio-irrigation. Second, a known concentration of bromide (a non-reactive constituent) was added to the benthic-flux chamber at the beginning of each deployment. Knowing the initial concentration of bromide in the chamber and its molecular diffusion coefficient, and assuming the porewater contains negligible concentrations of bromide, one can predict the flux of bromide to the

sediments. The predicted fluxes agreed with measured fluxes, indicating that the transport occurred primarily by molecular diffusion. Third, the activity of radon-226, the parent nuclide for radon-222, was measured in sediments at the two deployment stations. Knowing the activity of radon-222 in the sediment and the molecular diffusion coefficient for radon-222, one can predict the flux of radon-222 to the overlying water. The predicted and measured benthic fluxes of radon-222 were in agreement and thus provided further support that transport across the sediment-water interface in Coeur d'Alene Lake is controlled primarily by molecular diffusion.

#### **5.5.4 Organic Matter Diagenesis**

The flux of dissolved metals and other chemical species across the sediment-water interface is a result of the coupling of physical, chemical, and biological processes (Santschi et al. 1990). Biologically mediated chemical reactions can mobilize dissolved metals from solid phases within the lakebed sediments. The dissolved species can then be transported by molecular and eddy diffusion. The most important biochemical reactions in the upper sediments of aquatic environments involve the oxidation of organic matter. This process affects the partitioning of certain metals between sediment and porewater and produces nutrients such as ammonia and orthophosphorus that are needed for phytoplanktonic production. Studies of the diagenesis of organic matter in freshwater and marine sediments indicate that the oxidation of organic matter proceeds using a thermodynamically predictable sequence of oxidants: oxygen, nitrate, manganese oxyhydroxides, ferric oxyhydroxides, and sulfate (Froelich et al. 1979; Berner 1980; Pedersen and Loshner 1988; and Luther et al. 1998). These reactions are reflected in the composition of porewater as a function of depth.

With increasing depth, the observations include the disappearance of oxygen and nitrate, followed by the appearance of reduced nitrogen species ( $\text{NO}_2$  and  $\text{NH}_3$ ) and dissolved manganese and iron, and then the disappearance of sulfate. Oxygen is the primary oxidant of organic matter in the oxic zone. Suboxic conditions occur when oxygen concentrations are very low and nitrate, manganese oxyhydroxides, and ferric oxyhydroxides are used as oxidants. The location of this zone in the upper sediments of Coeur d'Alene Lake is of particular interest with respect to metals because the reduction of manganese and ferric oxyhydroxides can result in the release of associated metals (cadmium, copper, lead, and zinc) into the dissolved phase. The absence of oxygen and oxidation of organic matter by sulfate characterize anoxic conditions. Sulfate reduction results in the production of sulfide. This sulfide either appears in the porewater or is precipitated as a metal sulfide phase, if there are sufficient concentrations of dissolved metals (primarily iron). The depths where these reactions occur can be large (meters) or small (millimeters to centimeters) depending on the supply of organic matter, bottom-water anoxia, and sedimentation rates.

If these reactions are compressed into the upper few centimeters just below the sediment-water interface, then concentrations of oxygen, nitrate, and sulfate should be lower in porewater just below the interface, relative to concentrations in the overlying water as a result of diagenesis of organic matter. Thus, the direction of benthic fluxes for these chemical species should be into the sediment. Porewater profiles of sulfate within the upper 30 cm of Coeur d'Alene Lake sediments suggest that the transition from oxic, through suboxic, to anoxic conditions exists, depending on location, either within the upper 1 cm or the upper 2 to 5 cm just below the interface (Balistrieri 1998). Kuwabara et al. (2000) measured oxygen benthic fluxes that were -6.0 to -9.5 millimoles of oxygen per square centimeter per day, consistent with oxygen consumption by the sediments. Analytical methods employed by Kuwabara et al. (2000) did not separate nitrate and nitrite concentrations, so no benthic fluxes were determined for nitrate alone. Almost all benthic fluxes of sulfate calculated from the data in Balistrieri (1998) and summarized in Table 5.5-2 are negative, indicating that the sediments act as a sink for sulfate.

In contrast, oxidation of organic matter produces reduced nitrogen species ( $\text{NO}_2$  and  $\text{NH}_3$ ), orthophosphorus, and dissolved manganese and iron. The concentrations of these species should be higher in porewater relative to the overlying water. Thus, the direction of benthic fluxes for these species should be out of the sediments, assuming that no other reactions trap them within the sediments. For example, when a thin oxic layer overlies a suboxic or anoxic layer, dissolved iron produced in the suboxic zone can diffuse into the oxic zone to be oxidized and precipitated as solid-phase iron. This solid-phase iron could then adsorb dissolved orthophosphorus. This process would effectively trap both iron and orthophosphorus in the sediment and prevent them from diffusing into the overlying water. However, benthic flux data strongly suggest that the sediments in Coeur d'Alene Lake act as a source of dissolved iron and orthophosphorus, as well as ammonia and manganese, to the overlying water (Tables 5.5-2 and 5.5-3).

The oxidation of organic matter can indirectly mobilize or sequester metals such as cadmium, copper, mercury, lead, and zinc. If we assume that these metals are predominately supplied to the sediments in particulate form and in association with iron and manganese oxides, then the reduction of iron and manganese oxides during organic matter oxidation results in the release of not only dissolved iron and manganese, but all the other metals associated with those phases. The dissolved metals can either be transported by molecular or eddy diffusion across the sediment-water interface, or if there are sufficient concentrations of sulfide present, be precipitated or co-precipitated as authigenic metal-sulfide phases. Although authigenic sulfides may be forming (Harrington et al. 1998), most of the benthic flux data indicate that the sediments in Coeur d'Alene Lake act as a net source of dissolved cadmium, copper, mercury, lead, and zinc to the overlying water (Table 5.5-2).

### **5.5.5 Comparison of Benthic and Riverine Fluxes for Water Year 1999**

The following comparison of benthic and riverine fluxes is restricted to the following dissolved constituents for which riverine load data were available: cadmium, lead, zinc, inorganic nitrogen, and orthophosphorus. In order to make the comparison, the riverine loads were converted to fluxes by dividing the load by surface area. Two surface areas were used, 110 km<sup>2</sup> for metals and 129 km<sup>2</sup> for nutrients. Metals were divided by the smaller value because about 85 percent of the lakebed has highly elevated metal concentrations (Horowitz et al. 1995). The benthic fluxes measured at the main-channel and Mica Bay stations were deemed representative of lakewide benthic fluxes on the basis of surficial lakebed sediment data reported by Horowitz, Elrick, and Cook (1993). Sediment-associated concentrations of cadmium, lead, and zinc measured in surficial lakebed sediments near the main-channel and Mica Bay stations were comparable to the lakewide median values for those three metals.

The comparison of benthic and riverine fluxes in Table 5.5-4 indicates that lead has the smallest benthic flux relative to its riverine flux, about 13 percent. Zinc and cadmium derived from benthic flux represented 75 and 58 percent, respectively, of their associated riverine fluxes. The benthic flux contributions for the two nutrients exceeded their riverine contributions, especially inorganic nitrogen which was nearly 150 percent of its riverine flux.

## **5.6 MASS BALANCES FOR METALS AND NUTRIENTS**

The evaluation of physical, chemical, and biological processes that produce water-quality conditions in Coeur d'Alene Lake was performed with a mass balance approach. An accounting was made of the riverine and benthic income of metals and nutrients in relation to the lake's output of metals and nutrients. Three levels of evaluation were performed: 1) annual loads, 2) monthly loads, and 3) modeling of dissolved zinc.

### **5.6.1 Annual Loads**

The annual values for inflow and outflow loads of metals (Table 5.1-1) and nutrients (Table 5.1-2) were used in conjunction with the benthic fluxes of metals and nutrients (Table 5.5-4) in order to develop an annual mass balance for Coeur d'Alene Lake. The 1999 water year was the only year with sufficient data for this evaluation because benthic fluxes were only measured in 1999. Two mass-balance models, one for dissolved constituents and the other for particulate constituents, were the basis for the evaluation; the models were presented in Balistrieri, Murray, and Paul (1995). The mass-balance model for dissolved constituents was as

follows:  $dC_{\text{dissolved}} = \text{riverine input} + \text{benthic input} - \text{transformation of dissolved to particulate fraction} - \text{riverine output}$ ; all the variables have units of kg/yr. The mass-balance model for particulate constituents was as follows:  $dC_{\text{particulate}} = \text{riverine input} + \text{transformation of dissolved to particulate fraction} - \text{sedimentation} - \text{riverine output}$ ; all the variables have units of kg/yr. The terms  $dC_{\text{dissolved}}$  and  $dC_{\text{particulate}}$  are normally assumed to be zero for a lake at steady state. This assumption was verified to be acceptable in that in-lake concentrations of the modeled constituents (Brennan et al. 2000) were quite similar during the modeled period, the 1999 water year. The equation for the dissolved constituents was solved initially to derive the one unknown variable, transformation of dissolved to particulate phase. The transformation variable was then used in the equation for the particulate constituents in order to derive its one unknown variable, sedimentation. Two variables in the models, transformation of dissolved to particulate fraction and sedimentation, both incorporate physical, chemical, and biological processes as well as uncertainty because they are derived by difference from measured variables such as input and output loads. Some of the uncertainty arises from differences in the robustness of the measured variables. The most robust data base was for riverine input and output loads because discharge and water-quality samples were collected frequently during the 1999 water year (Woods 2000a). The benthic fluxes were less robust because of their limited spatial and temporal resolution; benthic flux was measured only during mid-August of the 1999 water year and at only two locations. No information is available on the magnitude of temporal variations of benthic flux in Coeur d'Alene Lake.

The mass balances for dissolved cadmium, lead, zinc, inorganic nitrogen, and orthophosphorus are presented in Table 5.6-1; Table 5.6-2 lists the mass balances for particulate cadmium, lead, and zinc. The two nutrients are not included in the latter table because particulate concentrations were not measured for them. On an annual basis, approximately one-half of the dissolved zinc, inorganic nitrogen, and orthophosphorus input to the lake via riverine or benthic sources was transformed to the particulate fraction. About three-fourths of the dissolved cadmium input was transformed to particulates and nearly 87 percent of dissolved lead input was transformed to particulates. More than 90 percent of the particulate-associated metals were subjected to sedimentation, leaving small amounts of particulate cadmium, lead, and zinc for discharge from the lake into the Spokane River.

The partitioning of the three metals between dissolved and particulate fractions related largely to physical and chemical processes. Dissolved metals delivered to the lake via riverine inflow included colloiddally associated metals that were subjected to aggregation, complexation, and adsorption. These processes produced particles capable of sedimentation within the lake's water column, in addition to the sedimentation of particulate-bound metals delivered to the lake via riverine inflow. Non-colloidal, dissolved trace metals delivered to the lake were also subjected

to adsorption to the abundant metal oxides of iron, manganese, and aluminum, as well as silt and clay particles, carried into the lake by the Coeur d'Alene River. A portion of the benthic flux was subjected to adsorption to the large quantities of iron and manganese also released as positive benthic fluxes into the oxic hypolimnion.

Kuwabara et al. (2000) and Horowitz, Elrick, and Cook (1993) have reported the presence of orange, ferric-hydroxide-like coatings on sediment particles on the surficial lakebed sediments of Coeur d'Alene Lake. If the coatings are primarily ferric hydroxide, then the near-neutral pH of hypolimnetic water would favor adsorption of trace elements and ligands such as orthophosphorus (Kuwabara et al. 2000). Such adsorption and subsequent sedimentation to the lakebed indicates that benthic-metal fluxes were likely overestimated as a load source to the lake's water column. An important outcome of these physical and chemical processes was the transformation of a large portion of the dissolved metal loads into particulate loads. This transformed particulate load then became available for sedimentation to the lakebed along with the metal loads initially delivered to the lake in the particulate phase.

The mass balances of the two dissolved nutrients reflect the interaction of physical, chemical, and biological processes. Because of the biological processes, the fate and transport of the two nutrients were more complex than those affecting the three metals. The colloiddally bound portion of each nutrient (but especially orthophosphorus), would be subjected to sedimentation if aggregation, complexation, and adsorption processes produced denser particles. As with the metals, the benthic flux of orthophosphorus was likely overestimated as an output load source because of adsorption and sedimentation back to the lakebed sediments. The inorganic nitrogen derived via benthic flux would be less prone to adsorption, but the ammonia fraction would be subjected to nitrification within the oxic hypolimnion. Both nutrients were affected by biological processes because they are essential nutrients for phytoplankton production. Phytoplanktonic assimilation of dissolved inorganic nitrogen and orthophosphorus converted some of their dissolved fraction to a particulate, organically bound fraction. The resultant particulate fraction had several possible fates. Advective transport could physically remove the particles from the lake as outflow. Sedimentation could deliver the particles to the lakebed sediments where they would be subjected to remineralization or sediment burial. Or, the particles could be maintained within the water column by turbulence and undergo remineralization or uptake by zooplankton grazing.

### **5.6.2 Monthly Loads**

On the basis of the foregoing evaluation of annual loads, the lake's income for cadmium, lead, zinc, and orthophosphorus exceeds the amount discharged by the lake; whereas more inorganic

nitrogen is discharged than is received by the lake. With the exception of inorganic nitrogen, one might conclude that there is no need for a benthic flux to account for water-column concentrations of cadmium, lead, zinc, and orthophosphorus in Coeur d'Alene Lake; riverine sources are sufficient to account for such concentrations. However, such a conclusion becomes questionable when one evaluates plots of monthly input and output loads of metals and nutrients for Coeur d'Alene Lake. This phase in the evaluation of the lake's mass balances subdivided input and output loads into monthly values and evaluated them in relation to monthly variations in discharges, lake-stage, and inflow routing.

#### ***5.6.2.1 Dissolved Cadmium***

The monthly input loads of dissolved cadmium exceeded output loads in all months, regardless of discharge and inflow routing conditions (Figure 5.6.2-1). The low discharges in October carried input and output loads of similar magnitude; these were some of the smallest loads of the 1999 water year. By November, input loads had begun to increase more rapidly than output loads, even though discharges into and out of the lake had increased by nearly equal amounts. The trend of increased discharge continued into January; however, the disparity between input and output loads attained its maximum for the 1999 water year in January. The increased input loads during November through January were caused by increased concentrations delivered by the Coeur d'Alene River; the January concentrations were some of the largest for the water year (Figure 5.6.2-2). The increased dissolved concentrations were largely attributable to an increase in the relative proportion of groundwater delivered to the Coeur d'Alene River during winter discharge conditions. These elevated input concentrations were not reflected in the output concentrations (Figure 5.6.2-3) because input loads were delivered as underflow or interflow during October through December.

During February, input and output loads decreased in response to decreased discharge and a decline in the input concentration of dissolved cadmium. March marked the start of increased discharges which continued through May. During these three months, input loads were predominately delivered as overflow. Input concentrations declined during this period as snowmelt runoff helped dilute dissolved cadmium concentrations. Conversely, output concentrations increased during these three months as hypolimnetic water with a higher dissolved cadmium concentration was mixed into the upper water column by turbulence generated by increased discharges into and out of the lake. The net effect during March through May was a reduction in the disparity between input and output loads. By June, input and output loads were nearly equal.

Limnological sampling conducted during June 1999 found that the inflow plumes of the Coeur d'Alene and St. Joe Rivers traversed Coeur d'Alene Lake and exited into the Spokane River (Woods, 2000c). July through September was a period of low discharge into and out of the lake, which was at or near its maximum lake stage for the water year. Input and output loads of dissolved cadmium declined substantially in response to the decreases in discharge. However, concentrations of dissolved cadmium input to the lake increased steadily from July through September; again, in response to the increased proportion of groundwater-derived inflow to the Coeur d'Alene River. Conversely, output concentrations declined over these three months, indicative of losses of dissolved cadmium within the lake. Such losses could have resulted from biological uptake and binding of dissolved cadmium by phytoplanktonic primary production, the biological transformation of cadmium from the dissolved to the particulate fraction has been reported by Sigg (1985). Phytoplanktonic primary production in Coeur d'Alene Lake would likely have been at or near its annual maximum during the summer months.

#### **5.6.2.2 Dissolved Lead**

The monthly input loads of dissolved lead were much larger than output loads in most months (Figure 5.6.2-4), likely because of lead's propensity to adsorb to sediment particles and thus be subjected to sedimentation within the lake's water column. The variation in input loads correlated closely with discharge variations throughout the year. Such sediment-associated behavior suggests that a portion of the dissolved lead load was associated with fine particulate material capable of passing an 0.45  $\mu\text{m}$  filter. Unlike cadmium, the largest difference in input and output loads for dissolved lead was measured in May, during snowmelt runoff which was delivered as a combination of overflow and interflow. The smallest differences were measured in October and November and July through September, months of low discharge into and out of the lake.

The months of November through February had some of the smallest output loads of the water year; three of those four months received input loads as underflows. This attenuation of output loads likely resulted from geochemical transformations of dissolved lead to particulate lead in conjunction with hypolimnetic storage of dissolved lead as a consequence of underflow. Output loads steadily increased during March through May as hypolimnetic water with a higher dissolved lead concentration was mixed into the upper water column by turbulence generated by increased discharges into and out of the lake. The increase in dissolved cadmium concentrations caused by an increased proportion of groundwater inflow was not evident for dissolved lead concentrations; the range in dissolved lead concentrations in the Coeur d'Alene River was quite small (about 3 to 8  $\mu\text{g/L}$ ) and did not exhibit seasonal influence from groundwater such as was observed for dissolved cadmium concentrations (Figure 5.6.2-5). Again, this lack of groundwater

influence on dissolved lead is related to lead's propensity to adsorb to sediment particles. Outlet concentrations of dissolved lead ranged from about 0.01 to 2 µg/L (Figure 5.6.2-6) and demonstrated variations related to hypolimnetic storage, in-lake sedimentation, and water-column circulation in response to increased turbulence.

### **5.6.2.3 Dissolved Zinc**

Unlike cadmium and lead, dissolved zinc loads into and out of the lake had alternate periods in which one exceeded the other (Figure 5.6.2-7). During October through February and July through September, input loads exceeded output loads. However, during March through June, input loads were less than output loads. The monthly variation in dissolved zinc loads was similar to that of dissolved cadmium (Figure 5.6.2-1) and much different than that observed for dissolved lead (Figure 5.6.2-4). The low discharges in October carried input and output loads of similar magnitude; these were some of the smallest loads of the 1999 water year. By November, input loads had begun to increase more rapidly than output loads, even though discharges into and out of the lake had increased by nearly equal amounts. The trend of increased discharge continued into January. The disparity between input and output loads attained its maximum for the 1999 water year in December and January. The increased input loads during November through January were caused by increased discharges and increased concentrations delivered by the Coeur d'Alene River; the December and January concentrations were some of the largest for the water year (Figure 5.6.2-8). The increased dissolved concentrations were largely attributable to an increase in the relative proportion of groundwater delivered to the Coeur d'Alene River during winter discharge conditions. Output concentrations during November through January also increased even though input loads were primarily delivered as underflow or interflow during those months (Figure 5.6.2-9). The increased output concentrations occurred as hypolimnetic water, with a higher dissolved zinc concentration, was mixed into the upper water column by turbulence generated by increased discharges into and out of the lake. During February, input and output loads decreased substantially, largely in response to decreased discharge. March marked the start of increased discharges which continued through May. During these three months, input loads were predominately delivered as overflow. Input concentrations declined during this period as snowmelt runoff diluted dissolved zinc concentrations in the Coeur d'Alene River. Output concentrations also decreased during these three months, also in response to dilution.

The relationship between input and output loads changed during March through June; output loads exceeded input loads. If all of the input loads had been routed through the lake as overflow, then the output loads would have been equal to or less than the input load. The source of the output loads that were in excess of the input loads therefore had to come from within the lake. Two in-lake processes could account for these excess loads. In the first, some of the

dissolved zinc routed into the hypolimnion by underflows could have been held in temporary storage; increased water-column turbulence could have routed the stored zinc out of the lake. In the second, dissolved zinc contributed by benthic flux could have enriched the hypolimnion; increased water-column turbulence could have routed the benthos-derived zinc out of the lake. July through September was a period of low discharge into and out of the lake, which was at or near its maximum lake stage for the water year. The relationship between input and output loads changed again; input exceeded output. Input and output loads of dissolved zinc declined substantially in response to the decreases in discharge. However, concentrations of dissolved zinc input to the lake, as overflows, increased steadily from July through September; again, in response to the increased proportion of groundwater-derived inflow to the Coeur d'Alene River. Conversely, output concentrations declined over these three months indicative of losses of dissolved zinc within the lake. Such losses could have resulted from biological uptake and binding of dissolved zinc by phytoplanktonic primary production, the biological transformation, of zinc from the dissolved to the particulate fraction has been reported by Sigg (1985). Phytoplanktonic primary production in Coeur d'Alene Lake would likely have been at or near its annual maximum during the summer months.

#### ***5.6.2.4 Dissolved Inorganic Nitrogen***

Similar to zinc, dissolved inorganic nitrogen loads into and out of the lake had alternate periods in which one exceeded the other (Figure 5.6.2-10). Input and output loads were nearly equal during October through November and during June through September. During December and January, input loads substantially exceeded output loads. During February through May, input loads were less than output loads; the disparity was particularly large in February through April. Input and output loads increased from October through January, in response to increased discharges into and out of the lake. Input loads increased at a more rapid rate, indicative of increased concentrations. These increases in concentration could have been due to an increase in the relative proportion of groundwater delivered to the Coeur d'Alene and St. Joe Rivers during winter discharge conditions, as well as the conversion of particulate organic nitrogen to dissolved inorganic nitrogen. In February, input and output discharges declined by about one-third; input loads dropped from about 65,000 to 15,000 kg, but output loads increased from about 40,000 to 45,000 kg. Note that February inflow was routed as underflow; dissolved inorganic nitrogen stored in the hypolimnion may therefore have been displaced into the upper water column where it became available for output to the Spokane River.

March through May was a period of increased discharges for inflow and outflow, with inflow delivered as overflow. The output of dissolved inorganic nitrogen reached the 1999 water year maximum of 62,000 kg in March and exceeded the March input load by about 30,000 kg. April

had similar conditions, but of a smaller magnitude. If all of the March and April input loads had been routed through the lake as overflow, then the output loads should have been equal to or less than the input loads. The source of the output load that was in excess of the input load therefore had to come from within the lake. Two in-lake processes could account for this excess load. In the first, some of the dissolved inorganic nitrogen previously routed into the hypolimnion by underflows could have been held in temporary storage; increased water-column turbulence during March and April could have routed the stored inorganic nitrogen out of the lake. In the second, dissolved inorganic nitrogen contributed by benthic flux could have enriched the hypolimnion; increased water-column turbulence could have routed the benthos-derived nitrogen out of the lake. Even with increased discharges, input and output loads began to decline during April and May, likely because of dilution by snowmelt runoff. Over the remaining months of the water year, input and output discharges and loads declined substantially and were nearly equal on a monthly basis.

#### ***5.6.2.5 Dissolved Orthophosphorus***

As with zinc and inorganic nitrogen, dissolved orthophosphorus loads into and out of the lake had alternate periods in which one exceeded the other (Figure 5.6.2-11). Output loads exceeded input loads during October through February; during the remaining seven months, input loads exceeded output loads. The variation in input loads correlated closely with discharge variations throughout the year; as did the input loads of dissolved lead discussed earlier (Figure 5.6.2-4). Such sediment-associated behavior suggests that a portion of the dissolved orthophosphorus load was associated with fine particulate material capable of passing an 0.45 Fm filter. Monthly variation in output loads was much less than that for input loads; this was indicative of geochemical adsorption and sedimentation of dissolved orthophosphorus loads within the lake. The months in which output loads exceeded input loads (October through February) were dominated by delivery of input discharge as underflow. Increased water column turbulence and underflow acted to displace dissolved orthophosphorus stored within the hypolimnion and make it available for discharge from the lake. The source of hypolimnetic dissolved orthophosphorus was a combination of riverine-derived loads and benthic-derived loads. From March through May, output loads of dissolved orthophosphorus changed little even though output discharges increased substantially. Such behavior indicates reductions in concentrations, probably as a result of dilution by snowmelt runoff and adsorption and sedimentation within the lake. From June through September, declining discharge resulted in parallel declines in output loads of dissolved orthophosphorus.

### 5.6.3 Modeling of Dissolved Zinc

Concentrations of dissolved zinc in Coeur d'Alene Lake are of concern because they exceed aquatic life criteria. One of the goals of remediation is to reduce the lake's zinc concentrations to less than the aquatic life criterion. The relative contributions of riverine and benthic-flux sources to the water-column concentrations of dissolved zinc need to be understood in order to determine what level of watershed remediation may be needed to achieve the aquatic life criterion in the lake. Therefore, the objective of the modeling described in this section was to analyze the relevant processes controlling dissolved zinc within Coeur d'Alene Lake.

The computer program AQUASIM (Reichert, 1994) was used for the modeling. AQUASIM is a tool for simulation and data analysis of aquatic systems. The calculations utilized the mixed reactor compartment of the program. A mass balance approach is used by AQUASIM as defined by the following equation:

$$dC_{Zn}/dt = I_{Zn} + P_{Zn} - O_{Zn} - R_{Zn} \quad (1)$$

where  $dC_{Zn}/dt$  is the change in concentration of dissolved zinc in the lake as a function of time (mg/L/d) and  $I_{Zn}$ ,  $P_{Zn}$ ,  $O_{Zn}$ , and  $R_{Zn}$  are, respectively, the sum of the rates (mg/L/d) of all external inputs, internal sources, outputs, and internal removal processes controlling dissolved zinc within the lake volume.

Coeur d'Alene Lake was treated as a single completely mixed system (i.e., one-box model). Dissolved zinc enters the lake through river inlets (i.e., Coeur d'Alene and St. Joe Rivers) and leaves through a single outlet (i.e., Spokane River). These processes are depicted by the  $I_{Zn}$  and  $O_{Zn}$  terms in equation 1. Benthic fluxes of dissolved zinc, represented by the  $P_{Zn}$  term in equation 1, act as an additional source of dissolved zinc to the lake, while scavenging of dissolved zinc to particulate zinc removes dissolved zinc from the lake (i.e.,  $R_{Zn}$ ). This box model is shown in Figure 5.6.3-1; the processes are in italics.

The next step was to mathematically define each of the terms on the right-hand side of equation 1 starting with  $I_{Zn}$ .

$$I_{Zn} = (Q_{in} * C_{Znin})/V \quad (2)$$

where  $Q_{in}$  is the discharge into the lake (L/d),  $C_{Znin}$  is the concentration of dissolved zinc in the inflowing water (mg/L), and  $V$  is the volume of the lake (L). Because the lake model has no internal structure, the location and number of inlets was not relevant. The water balance is

described solely by the total amount of water that enters and leaves the lake and, therefore, the inflow is the sum of discharges from the Coeur d'Alene and St. Joe Rivers.

The benthic flux term,  $P_{Zn}$ , describes the transport of dissolved zinc across the sediment-water interface by molecular diffusion.

$$P_{Zn} = q_{ex} * (C_{Znpw} - C_{Zntot}) \quad (3)$$

where  $q_{ex}$  is the molecular diffusion coefficient of dissolved zinc (1/d),  $C_{Znpw}$  is the concentration of dissolved zinc in the porewater, and  $C_{Zntot}$  is the total concentration of dissolved zinc in the water column of the lake.  $C_{Zntot}$  is the sum of dissolved zinc derived from the riverine source ( $C_{Zn1}$ ; produced from the  $I_{Zn}$  term) and the benthic flux source ( $C_{Zn2}$ ; produced from the  $P_{Zn}$  term). Dissolved zinc is lost from the lake by transport through the outlet as defined by  $O_{Zn}$ .

$$O_{Zn} = (Q_{out} * C_{Zntot})/V \quad (4)$$

where  $Q_{out}$  is the discharge at the outlet (L/d). The scavenging or transformation of dissolved to particulate zinc is represented by  $R_{Zn}$  and is described by a first order reaction.

$$R_{Zn} = (k_{scav} * C_{Zn1}) + (k_{scav} * C_{Zn2}) = k_{scav} * C_{Zntot} \quad (5)$$

where  $k_{scav}$  is the first order scavenging rate coefficient (1/d).

Several scenarios were modeled. First, the discharge at the inlet and the concentration of dissolved zinc in the inflow and outflow were held constant for the entire year. Scavenging was not considered initially, but was added in a subsequent model run. Second, the discharge at the inflow and the concentrations of dissolved zinc in the inflow and outflow were varied for each month of the year. Data from water year 1999 (WY99) were used (Brennan et al., 2000). The model was run for 3 years with each year having the parameters of WY99. The parameters used in the modeling are summarized in Tables 5.6-3 and 5.6-4.

The modeling was based on the following assumptions:

1. The initial conditions assume that the concentrations of dissolved zinc in the lake derived from riverine inflow ( $C_{Zn1}$ ) and the benthic flux ( $C_{Zn2}$ ) are zero at time  $(t) = 0$ .

2. The inflow is equal to the outflow or, in other words, the volume of the lake does not change as a function of time. This assumption is a fairly good approximation as the lake volume changes by less than 9 percent throughout the year.
3. The discharge into the lake and the mean dissolved zinc concentration in the inflow water are composed of a 1:1 mixture of Coeur d'Alene and St. Joe Rivers. For example, during WY99 the Coeur d'Alene River had a mean dissolved concentration of zinc of 212 mg/L, while the concentration of dissolved zinc in the St. Joe was 2.7 mg/L, thereby yielding 107 mg/L for dissolved zinc in the total inflow.
4. The exchange of dissolved zinc across the sediment-water interface is due to molecular diffusion and, therefore, a molecular diffusion coefficient can be used to describe this process (see Equation 3). This assumption is supported by the work of Kuwabara and others (2000). The value for the molecular diffusion coefficient of dissolved zinc at bottom water temperatures was obtained from Balistrieri (1998).
5. The value for the benthic flux of dissolved zinc into Coeur d'Alene Lake is the mean of the benthic flux chamber measurements made in Mica Bay and the main channel in Coeur d'Alene Lake during August 1999 and is equal to  $314 \text{ mg/cm}^2/\text{y}$  (Kuwabara and others, 2000). Equation 3 is used to back calculate the concentration of dissolved zinc in the porewater ( $C_{\text{Znpw}}$ ) that is needed to support such a benthic flux when the concentration of dissolved zinc in the lake is 67 mg/L (i.e., the mean annual dissolved zinc concentration in the lake, which is equal to the concentration in the outflow). This calculation yields 1609 mg/L for dissolved zinc in the porewater, which is at the high end of measured concentrations of dissolved zinc in porewater from sediment cores (Balistrieri, 1998).
6. The scavenging of dissolved zinc to particulate zinc is described by a first order rate constant (see Equation 5).
7. Scavenging of dissolved zinc derived from the riverine input is the same as scavenging of dissolved zinc derived from the benthic flux source. In other words, there is no difference in the chemical behavior or speciation of dissolved zinc from either source.

In the initial model runs in which scavenging was not assumed, the model calculations for the average annual case indicated that dissolved zinc concentration in the lake would be 154.2 mg/L with a riverine contribution of 106.7 mg/L and a benthic flux contribution of 47.6 mg/L. Because the measured outflow concentration was 67 mg/L and volumes of inflow and outflow were equal, these results suggest that some process (e.g., scavenging) removes and traps about 56 percent of the dissolved zinc that enters the lake.

Subsequent model runs employed scavenging and constant discharge conditions. Dissolved zinc concentrations as a function of time for these simulations are presented in Figure 5.6.3-2. A value of  $k_{\text{scav}} = 0.009/\text{d}$  was needed to achieve a dissolved zinc concentration in the lake ( $C_{\text{Zntot}}$ ) of 66.4 mg/L, which corresponds to the observed mean annual dissolved zinc concentration in the lake and outflow of 67 mg/L. Utilizing a value of  $0.01/\text{d}$  for  $k_{\text{scav}}$  yields a dissolved zinc concentration of 62.4 mg/L, while  $k_{\text{scav}} = 0.008/\text{d}$  produces a dissolved zinc concentration of 70.9 mg/L. The model results presented in Figure 5.6.3-2 indicate that 67.9 percent, or 45.1 mg/L, of the dissolved zinc in the lake is derived from the riverine input ( $C_{\text{Zn1}}$ ), while 32.1 percent, or 21.3 mg/L, of dissolved zinc in the lake is derived from the benthic flux ( $C_{\text{Zn2}}$ ).

Results of the model calculations that consider variations in the inflow volumes and dissolved zinc concentrations as a function of time, as well as scavenging, are presented in Figure 5.6.3-3. In this simulation, the dissolved zinc attributed to the river inflow changes, as expected, with seasonal loading from the Coeur d'Alene and St. Joe Rivers. The dissolved zinc in the lake derived from the benthic flux also varies as a function of time in response to the changing gradient in dissolved zinc across the sediment-water interface. Because the gradient is defined by the difference in concentrations of dissolved zinc in the porewater and in the lake (see equation 3), changes in the lake concentration influence the gradient across the interface. The relative importance of riverine and benthic flux inputs of dissolved zinc to the lake vary throughout the year. During the first quarter of the water year (October through December) inputs of dissolved zinc to the lake are greater from the benthic flux source than from the riverine source. The reverse is true during the remainder of the year.

Values of the first order scavenging rate coefficient that are needed to fit the measured dissolved zinc concentrations in the outflow are shown in Figure 5.6.3-4. Values of  $k_{\text{scav}}$  range about an order of magnitude from 0.003 to 0.027/d. The highest values are observed in the latter quarter of the water year (July through September) and, as might be expected, coincide with the minimum in dissolved zinc concentrations.

What is responsible for the variations in the scavenging rate coefficient? Some insight into this question is given by the work of Sigg et al. (1996). Although they examined a relatively pristine lake (Lake Greifen with zinc concentrations of 0.65-2.6 mg/L) compared to Coeur d'Alene Lake, the chemical behavior of zinc should be similar. Using sediment trap data, they found that the sedimentation of zinc (or transformation from dissolved to particulate fraction and subsequent settling) was related to sedimentation of algae and manganese dioxide. Since primary productivity is seasonal, they observed corresponding seasonal variations in the sedimentation of zinc. About 87 percent of the dissolved zinc that enters Lake Greifen was trapped within the lake compared to 56 percent in Coeur d'Alene Lake. Sigg et al. (1996) concluded that biological mechanisms of uptake and binding are significant for the removal of dissolved zinc from the water column in their system. The largest scavenging rate coefficients for dissolved zinc determined for Coeur d'Alene Lake occurred during the period of maximum biological productivity. The variations of WWR zinc concentrations in the euphotic zone and lower hypolimnion of Coeur d'Alene Lake during 1991-92 (Figure 5.6.3-5) indicate that phytoplanktonic uptake and binding (adsorption) substantially reduced zinc concentrations during the active growing season (July-October). Additional research would be needed to better understand the mechanisms and the role of biology in controlling transformations of dissolved to particulate zinc in Coeur d'Alene Lake.

Assuming that all the important processes have been incorporated into the above model, then the most reliable data are the physical characteristics of the system (e.g., lake volume and surface area of sediment), the measured discharge and dissolved zinc concentrations for the inflows and outflow for WY99, and the molecular diffusion coefficient for dissolved zinc. The least well-known data are the benthic flux of dissolved zinc, the concentration of dissolved zinc in the porewater, and the parameterization of the removal of dissolved zinc from the water column. The main reason for the inadequacy of the latter data is the lack of data. There is little information on spatial values for benthic fluxes of dissolved zinc into Coeur d'Alene Lake and none on seasonal values. There are no available high quality data on the spatial or temporal concentration of dissolved zinc in the porewater. The removal of dissolved zinc from the water column was assumed to be due to transformations to the particulate fraction. However, there are no sediment trap data to support this assumption. In addition, this removal was assumed to be first order. There is limited information from in-situ microcosm studies in lakes that suggests the removal of dissolved metals is first order (Santschi et al., 1986; Anderson et al., 1987). Values from their whole lake experiments and microcosm studies using radiotracers range from 0.03 to 0.06/d for  $k_{\text{scav}}$  for zinc, which are at the high end of values determined by the modeling of dissolved zinc in Coeur d'Alene Lake. It should be noted that the 3-year model of Coeur d'Alene Lake was based on data obtained from one water year. This same data was used to examine the full 3-year period in order to stabilize initial calculations, setting most parameters to zero. This

does not reflect the variations of a real system. Ideally, data from multi-year sampling would be used for improved modeling.

Given the above qualifications, the modeling results indicate that, on average, the majority (about 68 percent) of the dissolved zinc in the lake's water column is due to riverine inputs, with the Coeur d'Alene River contributing much more loading than the St. Joe River. Exchange across the sediment-water interface accounts, on average, for 32 percent of the dissolved zinc in the lake.

## **5.7 LAKE WATER QUALITY STATUS**

Water quality in Coeur d'Alene Lake is highly dependent on the interaction of the processes discussed in the preceding sections: mass balances of water and constituents, hydrodynamics, sedimentation, geochemical transformations, and lakebed fluxes of constituents. The status of water quality in the lake resultant from fate and transport processes was evaluated using the following four sources of information: 1) the USGS report for the 1991-92 limnological study of the lake (Woods and Beckwith 1997); 2) the IDEQ report for the 1995-99 monitoring of the lake (IDEQ 2000); 3) the database developed from the 1995-99 monitoring (Harvey 2000), and 4) the database developed from monitoring of the lake during the water year 1999 (Woods 2000c). The following discussion is subdivided into selected water-quality indicator variables. The available data are first reviewed and then discussed in relation to fate and transport processes.

### **5.7.1 Trophic State**

The term "trophic state" refers to the biological productivity of a water body and, as such, integrates the interaction of physical, chemical, and biological processes. For ease of categorization, three trophic states commonly are defined: oligotrophic (or low productivity), eutrophic (high productivity), and mesotrophic (intermediate productivity). Numerous variables have been employed as a basis for trophic-state classification. Although no classification system is universally accepted, variables such as total phosphorus, total nitrogen, chlorophyll-a, and secchi-disc transparency frequently have been used to classify trophic state. The United Nation's Organization for Economic Cooperation and Development used these four variables to develop a statistically based open-boundary trophic-state classification system (Ryding and Rast 1989) which is shown in Table 5.7-1. This approach compensates for the overlap in classification that commonly occurs with fixed-boundary systems. Under the open-boundary system, a water body is considered to be classified correctly if three of the four variables are within two standard deviations of their geometric mean for the same trophic state.

Annual geometric mean values for total phosphorus, total nitrogen, chlorophyll-a, and secchi-disc transparency were computed for Coeur d'Alene Lake for 1991-92 using data from six limnological stations. On the basis of lakewide geometric mean concentrations of total phosphorus ( $4.1 \mu\text{g/L}$ ), total nitrogen ( $247 \mu\text{g/L}$ ), and chlorophyll-a ( $0.54 \mu\text{g/L}$ ), the lake was oligotrophic over those two years (Woods and Beckwith 1997). A lakewide geometric mean value of 4.5 m for secchi-disc transparency yielded a mesotrophic classification. Therefore, Coeur d'Alene Lake was oligotrophic during 1991-92, because three of the four trophic-state classification variables indicated oligotrophy.

The lake monitoring conducted by IDEQ during the summer and autumn months of 1995-99 measured two of the four trophic state classification variables at three limnological stations analogous to stations L.1, L.3, and L.4 (Figure 5.3.2-1). The lakewide geometric means for secchi-disc transparency, 7.7 m, during 1995-98 and total phosphorus concentration,  $7.8 \mu\text{g/L}$ , during 1995-99 both classified the lake as oligotrophic.

Stations L.3 through L.5 were monitored by the USGS for the four trophic state classification variables during June through October 1999 (Tables 5.7-2 to 5.7-6). Lakewide geometric means for total phosphorus, total nitrogen, chlorophyll-a, and secchi-disc transparency were, respectively,  $5.5 \mu\text{g/L}$ ,  $141 \mu\text{g/L}$ ,  $0.94 \mu\text{g/L}$ , and 6.3 m. These values classified the lake as oligotrophic.

### **5.7.2 Specific Conductance, pH, and Major Cations and Anions**

Specific conductance is a measure of the ability of water to conduct electricity and is typically proportional to the water's dissolved-solids concentration. The mean ratio of dissolved-solids concentration to specific conductance in Coeur d'Alene Lake during 1991-92 was 0.7, which is within the range of most natural waters. Specific conductance measurements in the lake ranged from 30 to 95 microsiemens per centimeter ( $\mu\text{S/cm}$ ), which is low compared with measurements in other natural waters (Hem 1985). The smallest values were measured during May through July of 1991 and reflected the dilutional effects of snowmelt runoff from the Coeur d'Alene and St. Joe Rivers. Some minor stratification with depth developed. The most pronounced vertical gradient occurred in conjunction with severe depletion of dissolved oxygen near the lakebed of the southernmost station.

During 1995-99, specific conductance at the IDEQ monitoring stations ranged from 34 to  $64 \mu\text{S/cm}$  over summer and autumn. Specific conductance measured by the USGS during June through October 1999 at stations L.3 through L.5 ranged from 31 to  $56 \mu\text{S/cm}$  (Brennan et al. 2000).

The lakewide range in pH during 1991-92 was 6.6 to 8.2. The general trend in pH was for larger values in the euphotic zone during late summer and smaller values in the hypolimnion during late summer and autumn. In the summer, pH in the euphotic zone increased in response to photosynthetic utilization of carbon dioxide, whereas pH in the hypolimnion decreased as carbon dioxide was added by decomposition of organic matter. Limnological monitoring of the lake by IDEQ during summer and autumn months of 1995-99 measured a range in pH of 6.3 to 7.9. Monitoring by the USGS during June through October 1999 measured a range in pH from 6.6 to 9.0 at limnological stations L.3 through L.5 (Brennan et al. 2000).

Concentrations of major cations and anions measured in the lake during 1991-92 were converted to milliequivalents to determine water type. On average, calcium represented 67 percent of the major cations, and bicarbonate represented 82 percent of the major anions; therefore, water in Coeur d'Alene Lake is a calcium bicarbonate type. Alkalinity and hardness during 1991-92 ranged, respectively, from 19 to 33 mg/L as CaCO<sub>3</sub> and from 16 to 28 mg/L as CaCO<sub>3</sub>. Hardness measured by the USGS during June through September 1999 ranged from 14 to 23 mg/L as CaCO<sub>3</sub>.

### **5.7.3 Nutrients**

#### **5.7.3.1 Nitrogen**

Nitrogen is an essential element for aquatic biota, and because its ratio of supply to demand is small, it may limit the growth of aquatic plants. The cycle of nitrogen in aquatic ecosystems is complex because most processes involving nitrogen are biologically mediated. In aquatic ecosystems, nitrogen commonly exists in the following forms: dissolved molecular nitrogen (N<sub>2</sub>), nitrogen-containing organic compounds, ammonia (NH<sub>3</sub>), ammonium (NH<sub>4</sub><sup>+</sup>), nitrite (NO<sub>2</sub><sup>-</sup>), and nitrate (NO<sub>3</sub><sup>-</sup>). Nitrogen concentrations in lakes are often reported as total ammonia plus organic nitrogen (commonly called Kjeldahl nitrogen), dissolved ammonia, and dissolved nitrite plus nitrate, and dissolved inorganic nitrogen (the sum of ammonia, nitrite, and nitrate). Total ammonia plus organic nitrogen represents the ammonia, ammonium, and organic nitrogen compounds in solution and associated with biotic and abiotic particulate material. The dissolved concentrations represent the ammonia (includes ammonium), nitrite plus nitrate, or inorganic nitrogen contained in filtrate that passes through a 0.45 µm filter; the filtrate may contain colloiddally-associated nitrogen that is smaller than 0.45 µm.

Total nitrogen concentrations in Coeur d'Alene Lake during 1991 ranged from <205 to 902 µg/L; in 1992, the range was smaller, <205 to 607 µg/L (Woods and Beckwith 1997). Dissolved inorganic nitrogen concentrations ranged from <7 to 332 µg/L in 1991 and from <6 to 153 µg/L

in 1992. The maximum concentration of dissolved inorganic nitrogen was measured in the anoxic hypolimnion of the southernmost limnological station in September 1991. For total nitrogen, the lakewide mean concentrations for 1991-1992 in the euphotic zone and hypolimnion, respectively, were 262 and 273  $\mu\text{g/L}$ . For dissolved inorganic nitrogen during 1991-92, the lakewide mean concentrations in the euphotic zone and hypolimnion were, respectively, 32.8 and 63.8  $\mu\text{g/L}$ .

The limnological monitoring conducted by IDEQ during 1995-99 did not analyze samples for nitrogen. Water-quality samples collected by the USGS from July through October 1999 at limnological stations L.3 through L.5 yielded a mean total nitrogen concentration of 156  $\mu\text{g/L}$  within the euphotic zone and 238  $\mu\text{g/L}$  within the hypolimnion (Tables 5.7-2 to 5.7-6). Similarly, the mean concentration of dissolved inorganic nitrogen in the euphotic zone was 16.7  $\mu\text{g/L}$ ; in the hypolimnion it was 108  $\mu\text{g/L}$ .

Hypolimnetic concentrations of dissolved inorganic nitrogen were about twice those in the euphotic zone of Coeur d'Alene Lake during 1991-92 and water year 1999. Several fate and transport processes were responsible for this gradient. The process of nitrification converts organic and ammonia nitrogen to nitrite and then nitrate under aerobic conditions. Organically-bound nitrogen produced in the euphotic zone by phytoplankton growth eventually settles downward through the water column where it is subjected to nitrification, with a consequent increase in hypolimnetic concentrations of dissolved inorganic nitrogen. Phytoplanktonic assimilation of dissolved inorganic nitrogen within the euphotic zone depletes that nutrient source, especially during the summer growing season, thereby accentuating the gradient between the euphotic zone and hypolimnion.

The positive and substantial benthic flux of dissolved inorganic nitrogen from the lakebed sediments to the overlying hypolimnetic waters was also an important factor in development of the gradient between the euphotic zone and hypolimnion. The routing of the inflow plume within the lake also affected the gradient in dissolved inorganic nitrogen. During much of the year, the plume delivered dissolved inorganic nitrogen to the euphotic zone as overflow. Concentrations of dissolved inorganic nitrogen delivered as overflow typically were within the lower one-half of the overall range in concentration for the year (Harenberg et al. 1992, 1993, 1994; Brennan et al. 2000) and thus helped to accentuate the gradient between the euphotic zone and hypolimnion. Conversely, the upper one-half of the overall range in dissolved inorganic nitrogen concentrations was delivered as an underflow plume during October through December, thereby enriching hypolimnetic concentrations.

### 5.7.3.2 *Phosphorus*

Phosphorus is also an essential element in the metabolism of aquatic plants. The orthophosphate ion,  $\text{PO}_4^{3-}$ , is directly available for metabolic use by aquatic plants. Eutrophication studies have focused heavily on phosphorus because it is the nutrient typically found to have the smallest supply-to-demand ratio for aquatic plant growth (Ryding and Rast 1989). Phosphorus concentrations in lakes are often reported as total phosphorus and dissolved orthophosphorus. Total phosphorus represents the phosphorus in solution and contained in or attached to abiotic and biotic particulate material. Dissolved orthophosphorus is determined from the filtrate that passes a filter with a nominal pore size of  $0.45\ \mu\text{m}$ ; the filtrate may contain colloiddally-associated phosphorus that is smaller than  $0.45\ \mu\text{m}$ .

Total phosphorus concentrations in Coeur d'Alene Lake during 1991 ranged from  $<1$  to  $192\ \mu\text{g/L}$ ; in 1992, they ranged from  $<1$  to  $25\ \mu\text{g/L}$  (Woods and Beckwith 1997). Dissolved orthophosphorus concentrations ranged from  $<1$  to  $100\ \mu\text{g/L}$  in 1991 and from  $<1$  to  $8\ \mu\text{g/L}$  in 1992. The large difference in maximum concentrations reflect the lower discharges of 1992 that delivered smaller loads of sediment-associated phosphorus to the lake. For total phosphorus, the lakewide mean concentrations for 1991-1992 in the euphotic zone and hypolimnion, respectively, were  $5.1$  and  $6.0\ \mu\text{g/L}$ . For dissolved orthophosphorus during 1991-92, the lakewide mean concentrations in the euphotic zone and hypolimnion were, respectively,  $1.3$  and  $1.8\ \mu\text{g/L}$ . Assimilation of dissolved orthophosphorus by phytoplankton during the summer growing season often is revealed by distinct declines in that nutrient along with concomitant increases in total phosphorus that are associated with phytoplankton. The conversion of dissolved to particulate phosphorus was masked in Coeur d'Alene Lake during 1991-92 because dissolved orthophosphorus concentrations were frequently at or below the analytical detection limit of  $1\ \mu\text{g/L}$ .

The limnological monitoring conducted by IDEQ during 1995-99 analyzed samples for total phosphorus, but not dissolved orthophosphorus. The mean concentrations of total phosphorus reported by IDEQ for the euphotic zone and hypolimnion were, respectively,  $9.1$  and  $17.4\ \mu\text{g/L}$ . Water-quality samples collected by the USGS from July through October 1999 at limnological stations L.3 through L.5 yielded a mean concentration of total phosphorus of  $7.1\ \mu\text{g/L}$  within the euphotic zone and  $7.2\ \mu\text{g/L}$  within the hypolimnion (Tables 5.7-2 to 5.7-6). The mean concentration of dissolved orthophosphorus in the euphotic zone was  $1.3\ \mu\text{g/L}$ . In the hypolimnion, it was  $1.6\ \mu\text{g/L}$ .

The gradient in dissolved orthophosphorus in Coeur d'Alene Lake during 1991-92 and the water year 1999 was much smaller than that for dissolved inorganic nitrogen. One explanation for the difference is the propensity for phosphorus to adsorb to particulate matter. This facilitates settling of phosphorus through the water column and deposition onto the lakebed.

Concentrations of dissolved orthophosphorus delivered to the lake via the inflow plume did not vary nearly as much as dissolved inorganic nitrogen; therefore, the inflow-plume routing did not have a strong influence on the gradient between the euphotic zone and hypolimnion. The positive and substantial benthic flux of dissolved orthophosphorus was not clearly expressed within the hypolimnion because the nutrient was rapidly adsorbed to the substantial quantities of iron and manganese that were concurrently released into the hypolimnion by positive benthic fluxes of those two dissolved elements.

#### ***5.7.3.3 Limiting Nutrient***

The limiting nutrient concept states that the ultimate yield of a crop will be limited by the essential nutrient that is most scarce relative to the specific needs of the crop (Welch 1980). This concept, in concert with the stoichiometry of the photosynthesis equation, led to formulation of nitrogen-to-phosphorus ratios (N:P). The ratio has been used extensively in eutrophication studies to determine whether nitrogen or phosphorus was the nutrient most likely to limit phytoplankton growth. The atomic ratio of nitrogen to phosphorus, 16N:1P, in the photosynthesis equation corresponds to a mass ratio of 7.2N:1P. Typically, N:P values are calculated using the biologically available forms of the two nutrients, dissolved inorganic nitrogen (DIN) and dissolved orthophosphorus (DOP). If DIN:DOP (by weight) is less than 7.2, then nitrogen may be limiting, whereas if DIN:DOP exceeds 7.2, then phosphorus may be limiting (Ryding and Rast 1989).

Nitrogen and phosphorus concentrations measured during 1991-92 at six limnological stations in Coeur d'Alene Lake were used to calculate DIN:DOP. The mean DIN:DOP values for the stations ranged from 17.1 to 38.3 and thereby indicated a strong tendency towards phosphorus limitation (Woods and Beckwith 1997). The limnological monitoring conducted by IDEQ during 1995-99 did not analyze samples for DIN or DOP. Samples collected by the USGS from June through October 1999 at limnological stations L.3 through L.5 yielded a mean DIN:DOP value of 13.2, indicative of phosphorus limitation.

#### **5.7.4 Chlorophyll and Phytoplankton**

Chlorophyll-a is the primary photosynthetic pigment of phytoplankton and, as such, is used as an estimator of phytoplanktonic biomass. Chlorophyll-a concentrations in Coeur d'Alene Lake

during 1991-92 ranged from  $<0.1$  to  $2.6 \mu\text{g/L}$ ; lakewide mean concentrations in 1991 and 1992 were  $0.5$  and  $0.8 \mu\text{g/L}$ , respectively. The higher mean concentration in 1992 may be attributable to the substantial reduction in 1992 discharges, which yielded an hydraulic-residence time nearly twice the average. The increased hydraulic-residence time may have reduced flushing of nutrients and phytoplankton out of the lake and allowed more time for phytoplankton populations to develop within the lake. In both years, the highest chlorophyll-a concentrations were measured in the lake's shallow, southernmost end. The limnological monitoring conducted by IDEQ during 1995-99 did not analyze samples for chlorophyll. Chlorophyll-a samples collected by the USGS from July through October 1999 at limnological stations L.3 through L.5 yielded a mean concentration of  $1.0 \mu\text{g/L}$  and ranged from  $0.55$  to  $2.7 \mu\text{g/L}$  (Tables 5.7-3 to 5.7-6).

The taxonomic composition of phytoplankton in Coeur d'Alene Lake comprised 65 genera during the 1991-92 limnological study (Woods and Beckwith 1997). The following six phyla were represented: Chlorophyta, or green algae; Chrysophyta, or yellow-brown algae; Cryptophyta, or cryptomonads; Cyanophyta, or blue-green algae; Euglenophyta, or euglenoids; and Pyrrophyta, or dinoflagellates. The lakewide range in density and biovolume for the 151 samples was 28 to 7,100 cells per milliliter (mL) and 6,100 to 1,500,000 cubic micrometers per mL, respectively. The dominant algal genera, based on density, were *Asterionella*, *Cyclotella*, and *Synedra*, all members of the subphylum Bacillariophyceae, or diatoms, of the phylum Chrysophyta. The Cyanophyta were incidental or absent from much of the lake, but constituted at least 10 percent of the phytoplankton density in the lake's southernmost end during the summer months. The Cyanophyta were numerically dominated by *Anabeana flosaquae*.

### 5.7.5 Dissolved Oxygen

In natural freshwater, the concentration of dissolved oxygen is affected by temperature, barometric pressure, production of oxygen by photosynthesis, consumption of oxygen by respiration and decomposition, and mixing of water masses. The ratio (expressed as a percent) of measured dissolved-oxygen concentration to that which would exist under saturated conditions at the same temperature and barometric pressure is useful for comparing dissolved oxygen when significant variations in temperature and barometric pressure exist, such as comparisons spanning time or depth.

The overall range in dissolved-oxygen concentrations over depth and time during the 1991-92 limnological study was 0 to  $13.6 \text{ mg/L}$ , with both extremes measured in the southernmost end of Coeur d'Alene Lake (Woods and Beckwith 1997). The highest concentrations at each of the six limnological stations were measured in the winter months in association with minimum water temperatures. This conforms to the inverse relation between dissolved oxygen and temperature.

Minimum concentrations at each station were measured in the hypolimnion during late summer or autumn when thermal stratification had reduced mixing of the oxygenated epilimnion with the hypolimnion. The minimum concentrations for the four deep stations north of the mouth of the Coeur d'Alene River ranged from 6.4 to 6.5 mg/L. The moderate-depth station south of the mouth of the Coeur d'Alene River had a minimum dissolved-oxygen concentration of 2.8 mg/L. Anoxia was measured in the lake's southernmost end.

The variation in percent saturation of dissolved oxygen over depth and time was similar in 1991 and 1992. Saturations greater than 100 percent were measured in the euphotic zone of each station during the summer months when photosynthetic production of oxygen exceeded oxygen consumption by respiration and decomposition. Maximum saturations ranged from 113 to 117 percent at the four deep stations and was 120 percent at the moderate-depth station. The dense beds of aquatic macrophytes and associated periphyton in the lake's southernmost end augmented phytoplanktonic oxygen production and yielded saturation as high as 133 percent. Minimum percent saturations were measured in the hypolimnion during late summer and autumn and corresponded with minimum dissolved-oxygen concentrations. Minimum saturation at the four deep stations ranged from 58 to 60 percent, was 28 percent at the moderate-depth station, and 0 percent under the anoxic conditions in the lake's southernmost end.

Dissolved-oxygen profiles collected by IDEQ during 1995-99 at Coeur d'Alene Lake indicated all concentrations were 6.1 mg/L or greater at the three deep limnological stations that corresponded to stations L.1, L.3, and L.4 (Figure 5.3.2-1). The minimum percent saturation at these three stations was 56 percent and was measured near the lakebed of station L.1 in mid-September 1998. Dissolved-oxygen data were also collected by IDEQ at the moderate-depth station (analogous to station L.5 in Figure 5.3.2-1) during 1995-98; the minimums for dissolved-oxygen concentration, 2.6 mg/L, and saturation, 25 percent, were measured near the lakebed in mid-September 1998 (Harvey 2000).

The USGS monitoring of the lake during the 1999 water year included dissolved-oxygen profiles at limnological stations L.3-L.5 from June through October (Woods 2000c). The range in dissolved-oxygen concentration and saturation at the two deep stations, L.3 and L.4 was 6.5 to 11.2 mg/L and 66 to 120 percent. The minimum values were measured in mid-September about mid-depth at station L.4. The range in dissolved-oxygen concentration and saturation at Station L.5 was from 3.8 to 11.1 mg/L and 37 to 129 percent; the minimum values were measured in mid-September, about 0.5 m above the lakebed.

### 5.7.6 Metals

The 1991-92 limnological study analyzed euphotic zone and hypolimnion samples for concentrations of total cadmium, lead, and zinc (Woods and Beckwith 1997); results are summarized in Table 5.7-7. Of the 145 samples analyzed for cadmium, 94 percent were below the analytical detection limit of 1 µg/L. Lead was above its analytical detection limit of 1 µg/L in about three-fourths of the 146 samples; the median concentration was 3.3 µg/L. The median concentration of zinc was 98.6 µg/L; 89 percent of the samples were above the analytical detection limit of 10 µg/L. Nearly all of the below-detection limit samples of lead and zinc were taken in the lake's southernmost end which is not affected by inflow from the Coeur d'Alene River. Lakewide, concentrations of cadmium were comparable between the euphotic zone and hypolimnion. Such was not the case for lead and zinc. Median concentrations of lead in the euphotic zone and hypolimnion were 2.4 and 4.4 µg/L, respectively. Similarly, the median concentrations of zinc in the euphotic zone and hypolimnion were 81.8 and 115 µg/L, respectively.

The limnological monitoring conducted by IDEQ included analyses of total and dissolved concentrations of cadmium, lead, and zinc for 1995-98 (Harvey, 2000); results are summarized in Table 5.7-7. Median concentrations of total and dissolved cadmium within the euphotic zone and hypolimnion were <0.5 µg/L. Euphotic-zone concentrations of total and dissolved lead had median values of <5 and <3 µg/L, respectively, whereas, hypolimnetic median concentrations were 8 µg/L for total lead and 4 µg/L for dissolved lead. Median concentrations of zinc in the euphotic zone were 74 and 79 µg/L, respectively, for total and dissolved concentrations. In the hypolimnion, total and dissolved zinc had median concentrations of 119 and 103 µg/L, respectively. Exceedances of ambient quality criteria are highlighted in Table 5.7-7. In general, concentrations of dissolved lead and zinc exceeded criteria.

Water-quality samples collected by the USGS from June through October 1999 at limnological stations L.3 through L.5 were analyzed for total and dissolved cadmium, lead, and zinc (Tables 5.7-8 to 5.7-12); results are summarized in Table 5.7-7. Median concentrations of total and dissolved cadmium in the euphotic zone were 0.24 and 0.22 µg/L, respectively slightly greater than the ambient water quality criteria (0.11 µg/L); in the hypolimnion, both median concentrations were 0.34 µg/L. Euphotic-zone median concentrations of total and dissolved lead were 0.86 and 0.17 µg/L, respectively, whereas within the hypolimnion, they were 1.5 and 0.26 µg/L, respectively. The median concentration of dissolved lead was less than the ambient water quality criteria of 0.66 µg/L. Median total zinc concentrations in the euphotic zone and hypolimnion were 45 and 80 µg/L, respectively. The median dissolved zinc concentration in the euphotic zone, 42 µg/L, was about one-half of that in the hypolimnion, 76 µg/L. The median

dissolved zinc concentration in the hypolimnion exceeded the ambient water quality criteria of 43 µg/L.

Water-quality samples collected in Coeur d'Alene Lake between 1991 and water year 1999 indicated positive concentration gradients between the euphotic zone and hypolimnion for cadmium, lead, and zinc. These concentration gradients resulted from several limnological processes. One important chemical process was the positive benthic flux of dissolved metals, particularly cadmium and zinc; the benthic flux of dissolved lead was also positive, but of a lesser magnitude. The overall effect of benthic flux on the lake's water column was muted by the abundance of iron and manganese released from the bottom sediments; which when coupled with oxidizing conditions within the hypolimnion, facilitated adsorption and precipitation reactions that recycled a portion of the benthic-derived cadmium, lead, and zinc back to the lakebed sediments. Metal concentration gradients were also established by physical processes such as the in-lake routing of the lake's inflow plumes and their associated metal loads. The St. Joe River's inflow was an important source of dilutional water because its metal loads are negligible in comparison to those delivered by the Coeur d'Alene River (Woods 2000a).

The concentration gradients produced by riverine inflow also demonstrated a temporal component. For example, dissolved cadmium concentrations delivered by inflow during the 1999 water year were in the lower one-half of their annual range during the summer when inflows were routed as overflow; however, when underflows were delivered during October through December, dissolved cadmium concentrations were in the upper one-half of their annual range (Woods 2000a). Dissolved lead concentrations delivered by inflow in the 1999 water year had a narrow range, from 4 to 8 µg/L, and thus did not clearly account for the gradient between the euphotic zone and hypolimnion. Unlike lead, dissolved zinc concentrations delivered by inflow had a wide range, from about 75 to 550 µg/L (Woods 2000a). Inflows routed as overflow tended to have dissolved zinc concentrations in the lower one-half of their annual range. Conversely, the underflow period from October through December carried dissolved zinc concentrations in the upper one-half of their annual range. The temporal component of the concentration gradients was also affected by biological processes. Phytoplanktonic adsorption of dissolved cadmium and zinc during the summer accentuated the gradients via reduction of metal concentrations within the euphotic zone. Concurrent settling and decomposition of organic matter served to increase mid-depth and hypolimnetic concentrations of metals.

## **5.8 EUTROPHICATION POTENTIAL**

The 1991-92 limnological study of Coeur d'Alene Lake (Woods and Beckwith 1997) addressed the eutrophication issue using water-quality data collected in the lake and its watershed, as well as empirical modeling. The trophic state of the majority of the lake was determined to be oligotrophic on the basis of concentrations of nitrogen, phosphorus, and chlorophyll-a. Despite its oligotrophy, the deeper areas of the lake had a substantial hypolimnetic dissolved-oxygen deficit, which is symptomatic of eutrophication.

### **5.8.1 Nutrient Load/Lake Response Model**

An empirical nutrient load/lake response model was used to determine the response of selected limnological variables, including the hypolimnetic dissolved-oxygen deficit, to incremental increases or decreases in nutrient loads to the lake. The model, named BATHTUB, was originally developed for the U.S. Army Corps of Engineers to alleviate some of the inadequacies of earlier empirical models. The BATHTUB model is a highly evolved version of empirical lake-eutrophication models. Its enhancements include nonlinear nutrient-sedimentation kinetics, inflow nutrient partitioning, seasonal and spatial variations, algal growth limitation factors, and the ability to model linked segments to account for important spatial variations in water quality. Walker (1981, 1982, 1985, and 1987) thoroughly describes the model's conceptual basis, development history, and application procedures. A detailed discussion of the application of BATHTUB to Coeur d'Alene Lake is presented by Woods and Beckwith (1997).

On the basis of simulation results from the nutrient load/lake response model, Coeur d'Alene Lake has a large assimilative capacity for nutrients and, thus, it is unlikely that the hypolimnetic dissolved-oxygen deficit would become large enough to develop an anoxic hypolimnion, unless nutrient loads to the lake increased substantially. The lake's susceptibility to eutrophication, a prerequisite for development of an anoxic hypolimnion, can likely be managed if nutrient loads to the lake are not allowed to increase appreciably over those measured in the 1991-92 limnological study.

### **5.8.2 Inhibition of Phytoplankton Production**

The presence of elevated metals concentrations in Coeur d'Alene Lake plays a role in the lake's eutrophication potential. Bioassays conducted in the early 1970's by Wissmar (1972) and Bartlett, Rabe, and Funk (1974) assessed the inhibitory effects of cadmium, copper, and zinc on the lake's phytoplankton growth. The two bioassays arrived at different conclusions regarding inhibition; however, the discrepancy was largely due to methodological differences.

The 1991-92 limnological study of Coeur d'Alene Lake found that zinc was the only trace element in the lake still well above its analytical detection limit. This result revived interest in the unresolved question of zinc inhibition of phytoplankton growth and, by extension, the potential for eutrophication of the lake. Therefore, current-technology bioassays were conducted in 1994 using phytoplankton isolated from the lake and chemically defined media formulated on the basis of geochemical data from Coeur d'Alene Lake. This approach accounted for speciation and bioavailability of zinc to phytoplankton that were adapted to the chemical conditions in the lake.

The three bioassays conducted in 1994 showed that phytoplankton growth (measured as mean cell numbers, biomasses, and doubling rates) was strongly inhibited by dissolved (0.2  $\mu\text{m}$  filter pore size) zinc concentrations greater than the basal media treatment (Kuwabara et al. 1994). Inhibition was particularly evident for *Achnanthes minutissima*, a pennate diatom known to be intolerant of elevated trace-element concentrations. Inhibition by dissolved, uncomplexed zinc began between concentrations  $>0.5 \mu\text{g/L}$ , the basal treatment, and  $<19.6 \mu\text{g/L}$ , the mid-level treatment. This concentration range lies well below the median concentration of about  $50 \mu\text{g/L}$  of dissolved (0.2  $\mu\text{m}$  filter pore size) zinc measured in the majority of Coeur d'Alene Lake during 1993-94 (Woods and Beckwith 1997). Concentrations of dissolved organic carbon (DOC), concurrently measured with zinc, were consistently low ( $<1.5 \text{ mg/L}$ ) in the lake. The low concentrations of DOC enhanced the bioavailability of dissolved zinc because DOC compounds represent an important source of ligands for chemically binding (complexing) metals such as zinc. The presence in Coeur d'Alene Lake of *Achnanthes minutissima* and *Cyclotella stelligera*, the two algal species used in the bioassays, was not inconsistent despite the bioassay's demonstrated toxic effects. The bioassay results did not indicate total mortality, but rather that growth and viability of these two algal species were inhibited to the point that they survived at a marginal level with reduced scope for growth and reproduction (Dixon 1999).

## **5.9 EXPORT OF METALS AND NUTRIENTS FROM COEUR D'ALENE LAKE**

The cumulative effect of the physical, chemical, and biological processes within Coeur d'Alene Lake determine the quantity of metals and nutrients exported to the Spokane River at the lake's surface-water outlet. The first USGS gaging station downstream of the lake is Spokane River near Post Falls, which is about 15 km downstream of the lake's outlet. The annual mean discharge and loads of cadmium, lead, zinc, total phosphorus, and total nitrogen measured at that station are listed in Table 5.9-1 for the seven water years with sufficient water-quality data for load calculations. In each year, the vast majority of cadmium and zinc exported from the lake was in the dissolved fraction. The opposite was the case for lead, only 15 percent of the

cumulative lead-load exported was in the dissolved fraction. During calendar year 1992 and water year 1999, dissolved orthophosphorus comprised 35 and 20 percent, respectively, of the exported total phosphorus load whereas dissolved inorganic nitrogen comprised 24 and 28 percent, respectively, of the exported total nitrogen load (Woods and Beckwith 1997; Woods 2000a).

The lake's annual retention of metals was a relatively consistent percentage for cadmium, lead, and zinc over a wide range of discharge conditions (Table 5.9-2). Percentage retention of total zinc ranged from 31 to 43 percent (median = 38) over four years representative of low (1994) to high (1997) discharge conditions. Percentage retention of total lead over the same four years was much higher, ranging from 82 to 92 percent (median = 92). Percentage retention of total cadmium was intermediate to that of zinc and lead, ranging from 47 to 56 percent (median = 52). The small variation in percentage retention for each metal indicates that the cumulative effects of physical, chemical, and biological processes within the lake are relatively unaffected by annual variations in discharge and metal loads.

Annual loads of total metals exported from the lake had strong, positive correlations with annual mean discharge from the lake. Correlation coefficients for cadmium, lead, and zinc were 0.90, 0.88, and 0.96, respectively. The same was true for dissolved trace-element loads; the correlation coefficients for cadmium, lead, and zinc were 0.84, 0.86, and 0.99, respectively. The two nutrients demonstrated the same positive relation with annual mean discharge, although only two years were available for comparison.

The strong positive correlation between discharge out of the lake and constituent loads exported to the Spokane River parallels the strong positive correlation between inflow discharges and their associated constituent loads into the lake. Note however that the strength of the correlation is due, in part, to the fact that load is the product of discharge and concentration. The lake hydrodynamics discussed earlier play an important role in the routing of constituent loads into and through the lake as well as their mixing within the lake's water column. The influence of these hydrodynamic processes on the fate and transport of constituent loads in the lake varies seasonally, but over a water year their net effect at the lake's outlet is largely expressed by discharge volume. The seasonality can be illustrated by the following three examples. A significant portion of the total constituent loads delivered to the lake during spring snowmelt runoff may be routed through the lake in less than a month as a combination of overflow and interflow. In the autumn, the outflow plume created by the Spokane River's drawdown of the lake may be the dominant process for transport of dissolved constituent loads from the lake. Convective overturn in the spring and autumn facilitate mixing of epilimnetic and hypolimnetic water masses and the total and dissolved constituents associated with each. The transport of the

mixed water mass out of the lake is then highly dependent on the magnitude of inflow and outflow discharge volumes.

## **5.10 SUMMARY OF FATE AND TRANSPORT IN COEUR D'ALENE LAKE**

The preceding discussions of fate and transport focused on the following three central questions. One, what happens to metals and nutrients after they enter the lake? Two, what is the role of the lakebed sediments in regulation of metal and nutrient concentrations in the lake's water column? Three, what determines the amount of metals and nutrients discharged from the lake into the Spokane River? The answers to those three questions were developed by integrating a large amount of hydrologic and water-quality data and information in order to examine the interaction of physical, chemical, and biological processes as they relate to the fate and transport of metals and nutrients in Coeur d'Alene Lake.

Once metals and nutrients enter the lake, either in a dissolved or particulate fraction, their fate and transport is highly dependent upon the lake's hydrodynamic characteristics. The lake's short hydraulic-residence time (about one-half year), coupled with a propensity for routing riverine inflows as overflow, facilitated advective transport of particulate and dissolved constituents within the lake. During periods of spring snowmelt runoff and winter rain-on-snow events, portions of the overflow plumes were routed through the lake and discharged into the Spokane River. Conversely, riverine inflows delivered in the late fall and early winter were often routed as underflows into the lake's hypolimnion. During periods of convective or discharge-induced water column mixing, constituents stored in the hypolimnion were circulated throughout the lake's water column.

Mass-balance calculations, using dissolved and particulate loads from riverine and benthic sources, indicated that about 50 percent of the dissolved zinc, inorganic nitrogen, and orthophosphorus that entered the lake was transformed to the particulate fraction. For dissolved cadmium, about 75 percent was transformed; about 90 percent of dissolved lead was transformed to particulate lead. For metals associated with the particulate fraction, about 90 percent were sedimented within the lake. Therefore, geochemical transformation of dissolved (including colloidal) constituents into the particulate fraction was an important process by which sedimentation of metals was augmented, in addition to those metal loads initially delivered to the lake in the particulate fraction. Biological processes also affected fate and transport of metals and nutrients. Phytoplanktonic assimilation of dissolved inorganic nitrogen and orthophosphorus converted those constituents into new particulate organic matter; that is, new phytoplankton. Such conversions were not necessarily unidirectional; subsequent death and lysis of

phytoplankton transformed particulates back to the dissolved fraction. Phytoplankton also affected dissolved metals via adsorption of dissolved cadmium and zinc; this process was well-illustrated by summertime declines in euphotic zone concentrations of dissolved zinc in Coeur d'Alene Lake. The net result of physical, chemical, and biological processes within the lake was to retain the following approximate percentages of its riverine and benthic input loads (dissolved plus particulate): cadmium, 50 percent; lead, 90 percent; zinc, 35 percent; nitrogen, 5 percent; and phosphorus, 30 percent.

The lakebed sediments played a role in the regulation of metal and nutrient concentrations within the lake's water column. The lake's substantial depth, routing of inflow plumes primarily as overflow, and sedimentation characteristics indicated that scouring of the lakebed sediments was an insignificant source for delivery of particulate and dissolved constituents back into the water column. Therefore, the lakebed sediments served as a major repository for metals and nutrients that had been removed from the water column via sedimentation. However, geochemical processes within the lakebed sediments and near the sediment-water interface facilitated releases of previously deposited metals and nutrients back into the lake's water column. On the basis of benthic-flux measurements made in August 1999, fluxes of dissolved cadmium, zinc, inorganic nitrogen, and orthophosphorus from the lakebed sediments were of similar magnitude to those delivered to the lake by the Coeur d'Alene and St. Joe Rivers. However, the contribution of these benthic fluxes to the lake's water column was muted by adsorption and sedimentation within the lower hypolimnion at or near the sediment-water interface.

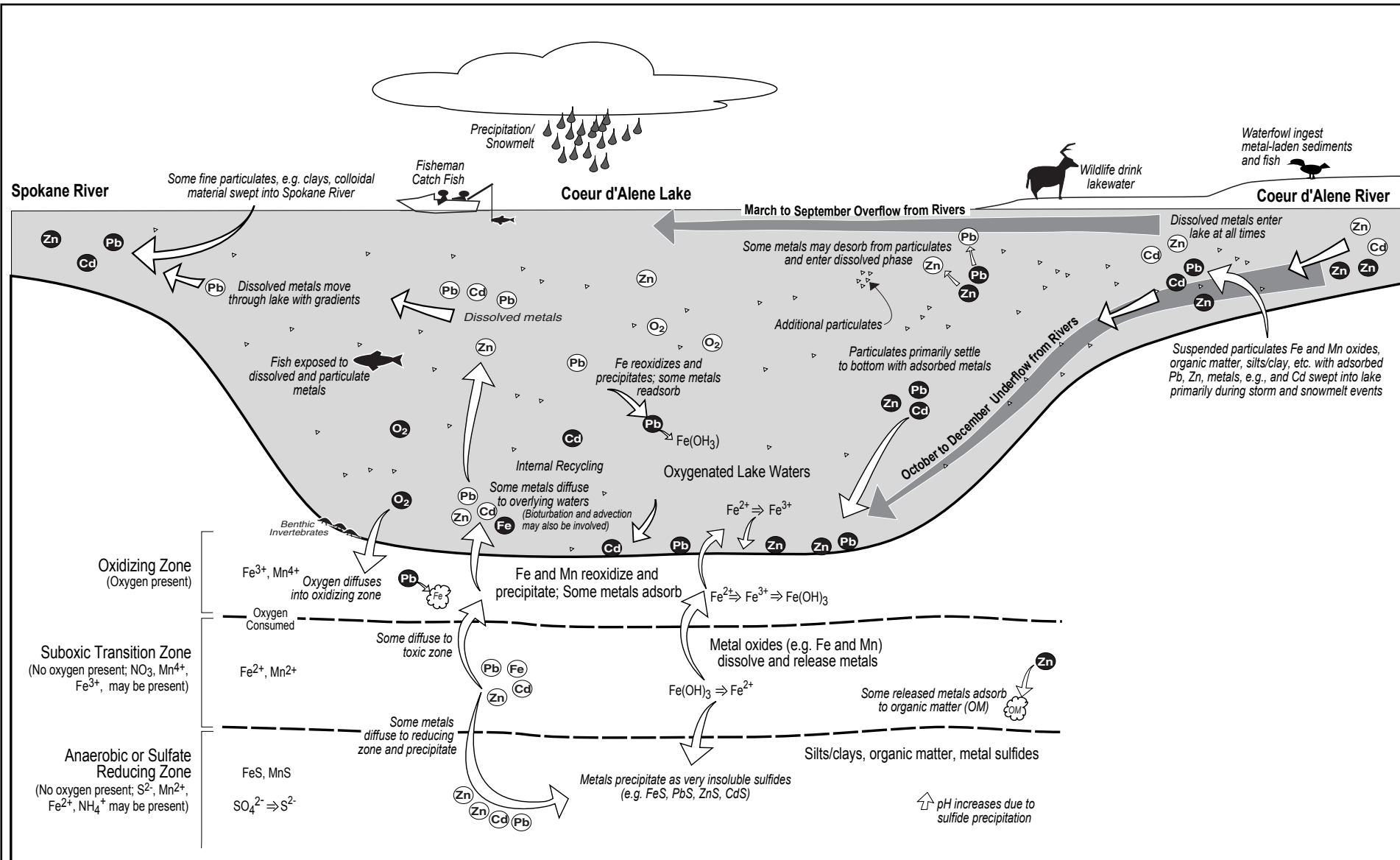
The mass balance of metals and nutrients in the lake was used to evaluate the relative contribution of riverine and benthic-flux loads on water-column concentrations. When calculated with annual loads, the mass balances indicated that, except for dissolved inorganic nitrogen, the riverine loads of cadmium, lead, zinc, and orthophosphorus were in excess of those discharged from the lake; therefore, one could conclude that benthic fluxes were not needed to account for water-column concentrations. When the mass balances were calculated with monthly loads, it was apparent that output loads exceeded input loads during parts of the year for dissolved zinc and inorganic nitrogen; thereby indicative of the potential for benthic fluxes to affect water-column concentrations of these two constituents. However, another geochemical process could also explain why output loads exceeded input loads during part of the year. If riverine-derived particulate matter was remineralized as it was delivered to the hypolimnion via sedimentation, then this transformed source of dissolved zinc and inorganic nitrogen could account for all, or part, of the excess output load. Given the established presence of a positive benthic flux, the internally generated supply of dissolved zinc and inorganic nitrogen is probably a combination of benthic flux and remineralization of riverine-derived loads.

The amount of metals and nutrients discharged from Coeur d'Alene Lake into the Spokane River is determined by the cumulative effect of in-lake physical, chemical, and biological processes acting on metals and nutrients delivered to the lake from riverine and benthic sources. One of the most important processes is sedimentation; either of particulate-bound metals and nutrients delivered by riverine inputs, or of particulate constituents formed by geochemical and biological transformations of dissolved constituents delivered either by riverine or benthic sources. The overall effect of sedimentation is to increase the ratio of dissolved to particulate constituents between their entry into the lake and their discharge from it. On a yearly basis, the majority of cadmium and zinc input to the Spokane River was in the dissolved fraction, whereas only about 15 percent of the lead was dissolved.

Annual discharge volume was another important influence on the amount of metals and nutrients discharged to the Spokane River from Coeur d'Alene Lake. Both dissolved and particulate loads had strong, positive correlations with discharge. Within a particular year, the temporal variation of discharge volume and the in-lake routing of inflows played an important role in determination of the amount of metals and nutrients discharged to the Spokane River. The predominance of overflow, especially, during periods of elevated inflow discharges, increased the frequency at which riverine loads of metals and nutrients could traverse the lake for delivery to the Spokane River. Alternatively, late autumn and winter inflows were usually routed as underflows into the hypolimnion. Underflows affected the hypolimnion in two important ways. Under low discharge conditions, hypolimnetic concentrations could be enriched as additional metals and nutrients were routed deep into the lake. Under elevated discharge conditions, the underflows could displace hypolimnetic water with its associated metal and nutrient loads and result in discharge out of the lake.

A large amount of hydrologic and water-quality data and information from numerous sources was employed in the foregoing evaluation of the fate and transport of metals and nutrients in Coeur d'Alene Lake. Obviously, a myriad of physical, chemical, and biological processes are in operation over a wide range of temporal and spatial scales. Given this complexity, no one process can be identified as being the "master variable" in control of the lake's metal and nutrient geochemistry. However, over a multiple-year time scale, the hydrological (physical) effects on the quantities of metals and nutrients delivered to and routed within the lake are very important determinants of the lake's existing water-column and lakebed-sediment geochemistry. The influence of chemical and biological processes also occur over a multiple-year time scale, but may be more easily detected within the context of seasonal changes within one year. Coeur d'Alene Lake is also spatially complex because of its long and narrow axis, irregular shoreline, and wide range in depth. Such spatial variability affects the relative influence of physical, chemical, and biological processes among different locations within the lake.

Several important issues remain unclear regarding the fate and transport of metals and nutrients in Coeur d'Alene Lake. Most notable is the relative role of riverine and benthic sources in determination of water-column concentrations and export of metals and nutrients to the Spokane River. Tied to that issue are the spatial and temporal effects of transformation and remineralization reactions on dissolved and particulate metals and nutrients within the water column and at the water-sediment interface.



Dissolved Metals    Particulates  
 Particulates (e.g. iron, organic matter) which adsorb metals

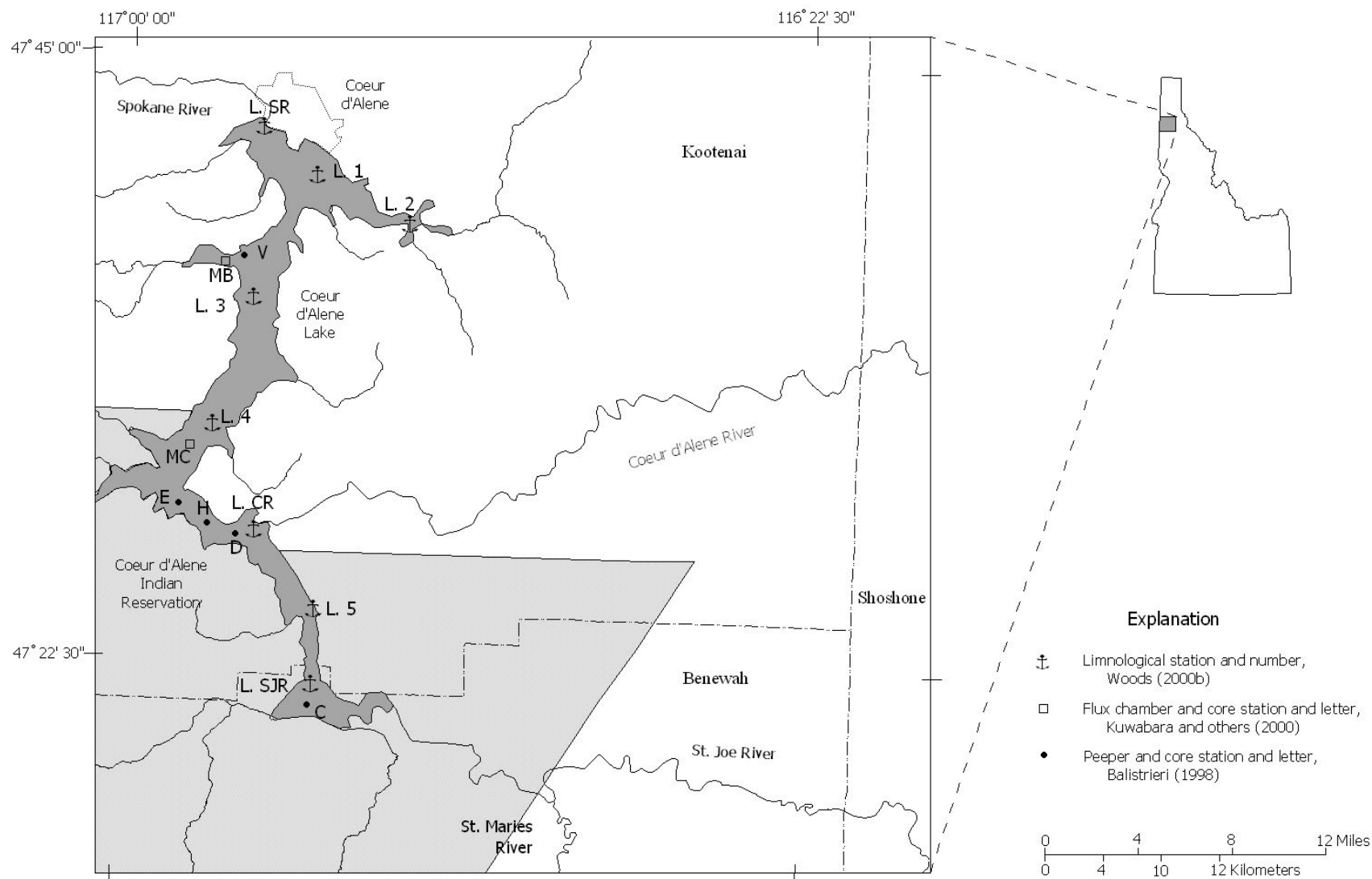


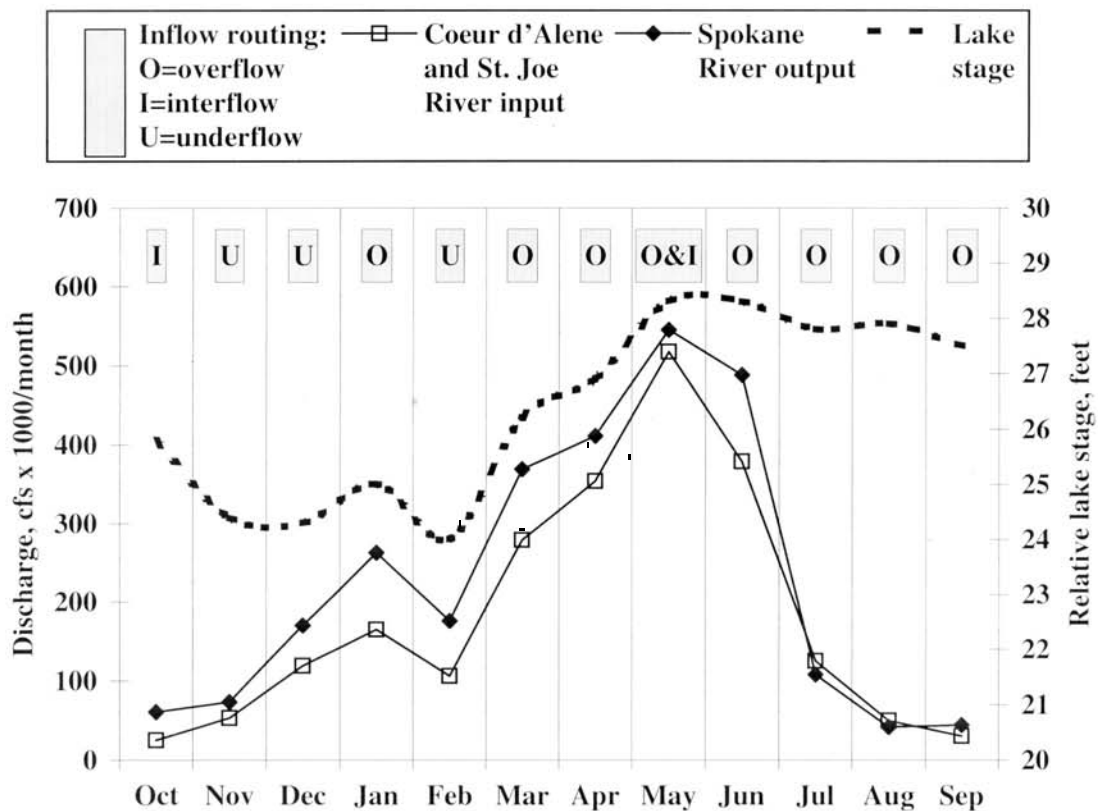
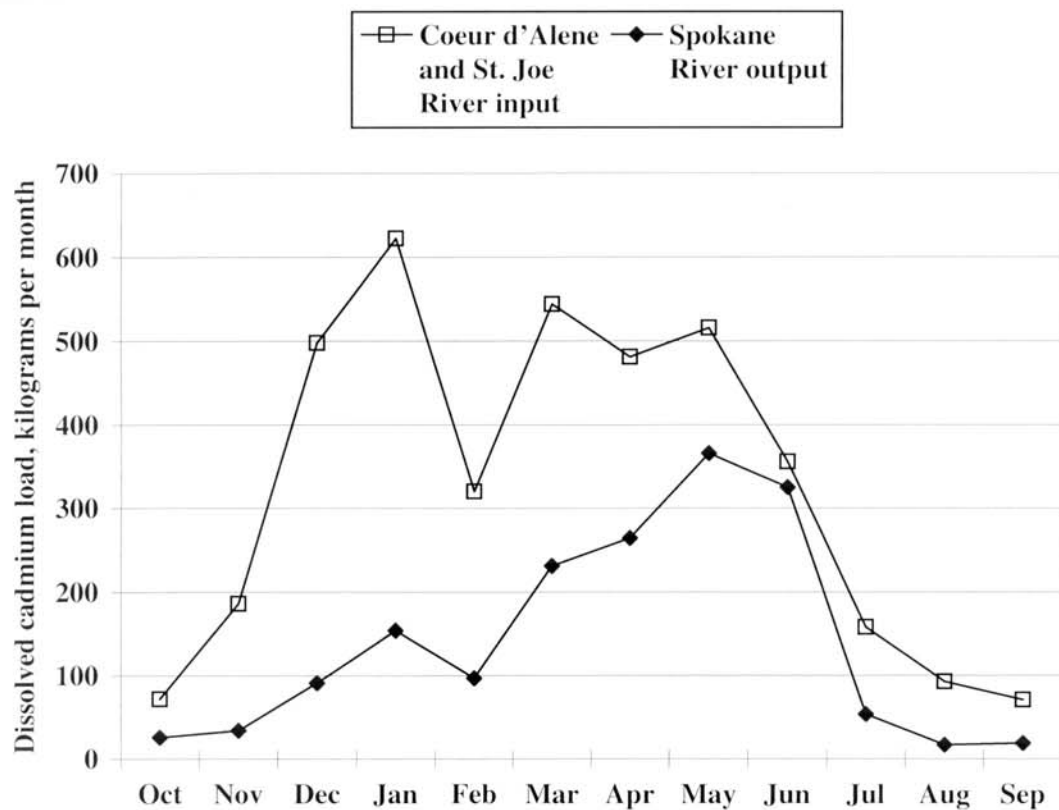
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**Figure 5-1**  
**Conceptual Model of Fate and Transport**  
**in Coeur d'Alene Lake**





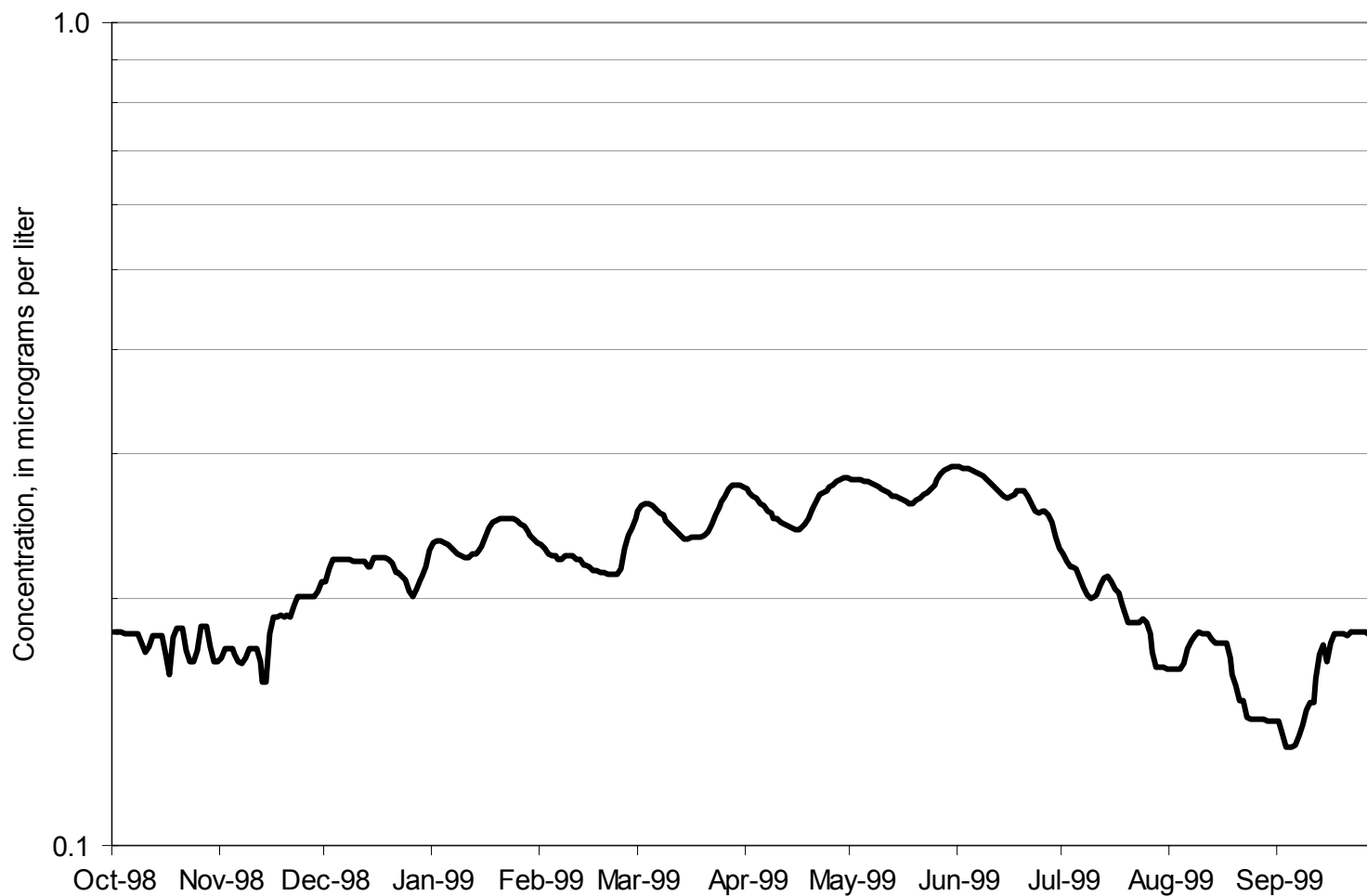


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Generation: 1

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**Figure 5.6.2-2**  
**Daily Concentrations of Dissolved Cadmium at Coeur d'Alene River**  
**near Harrison, ID, 1999 Water Year**

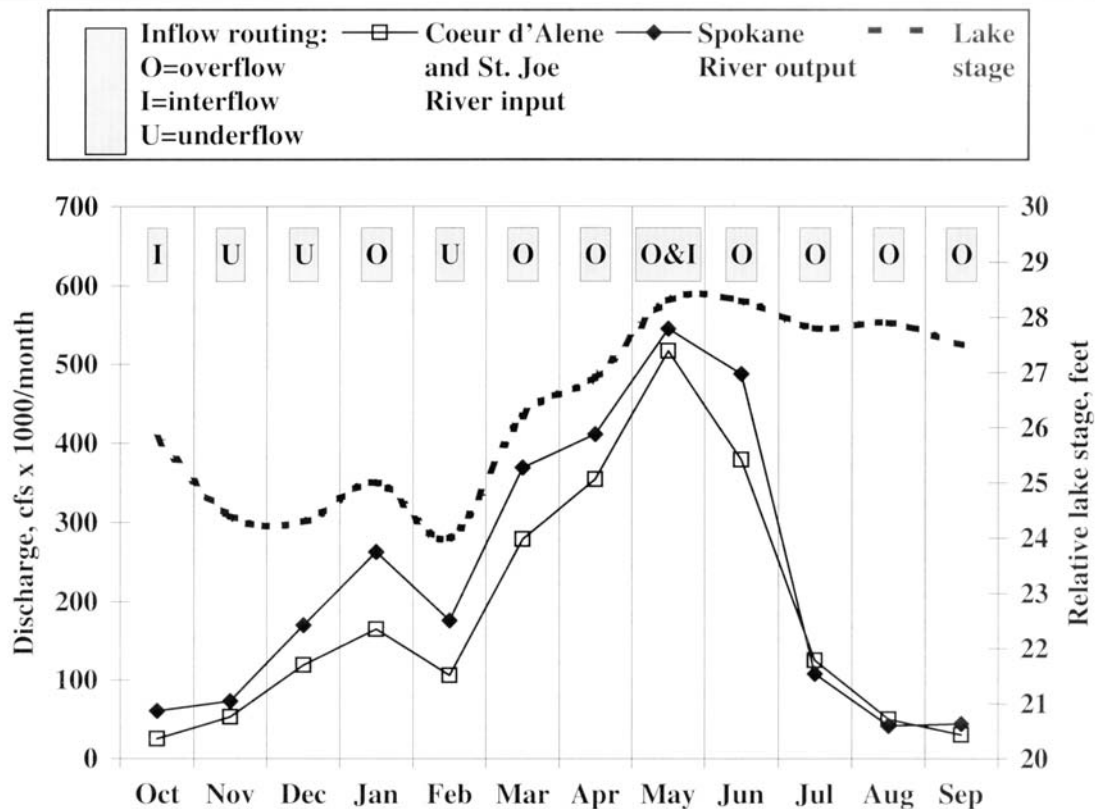
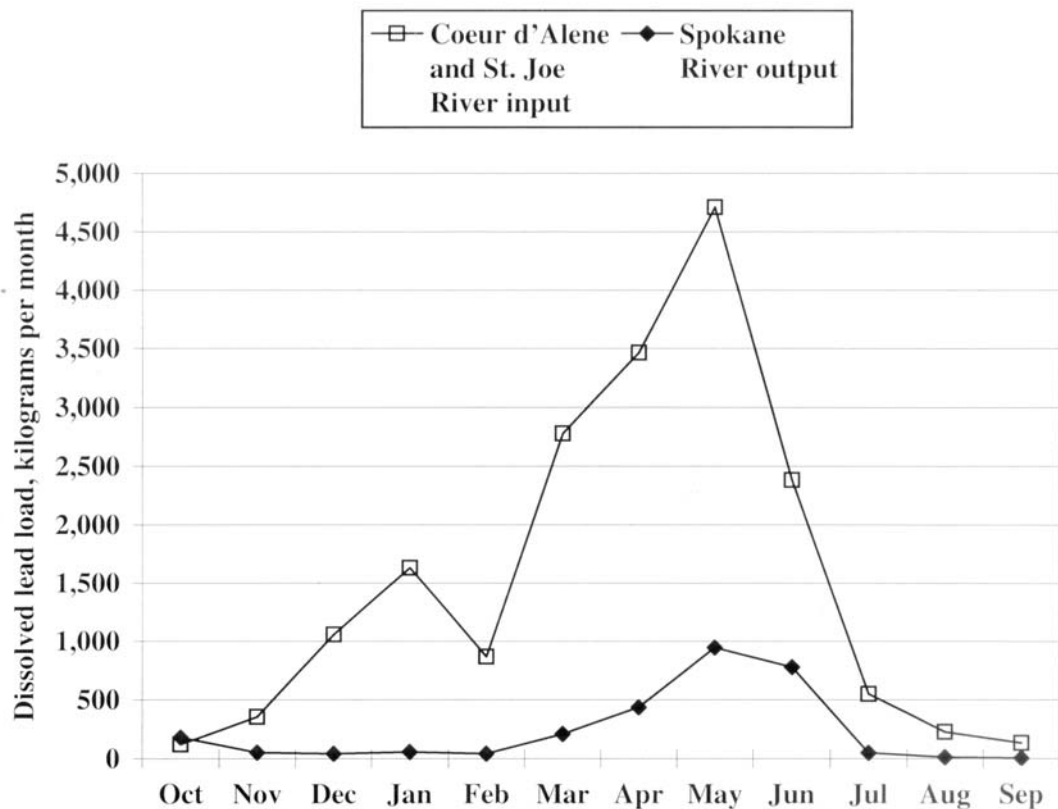


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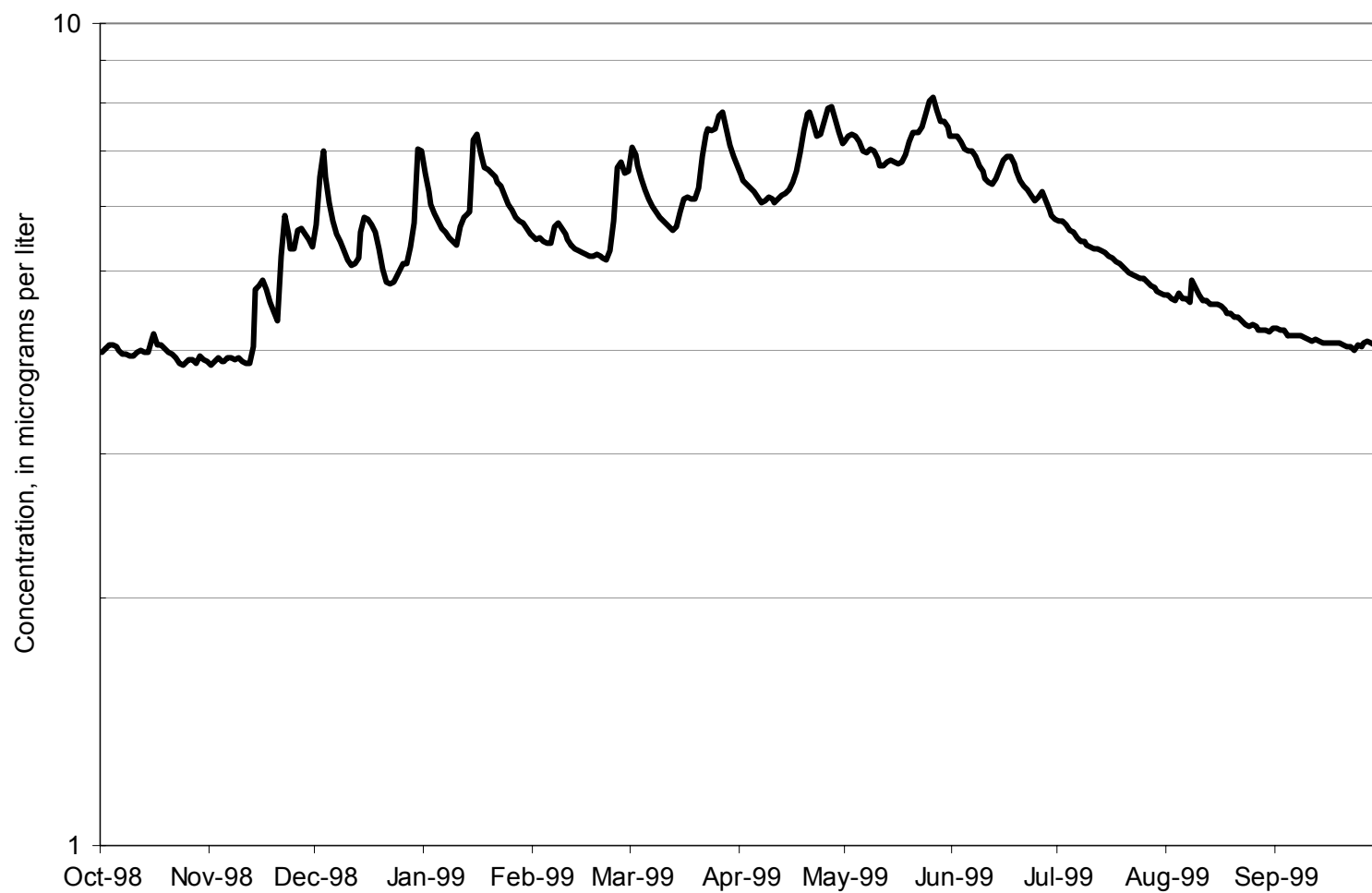
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Generation: 1

CDA Lake Series  
5/24/01

**Figure 5.6.2-3**  
**Daily Concentrations of Dissolved Cadmium at Spokane River Near**  
**Post Falls, ID, 1999 Water Year**



**Figure 5.6.2-4**  
**Monthly Values for Dissolved Lead Loads, Discharge, Lake Stage, and Inflow Routing, Coeur d'Alene Lake, 1999 Water Year**

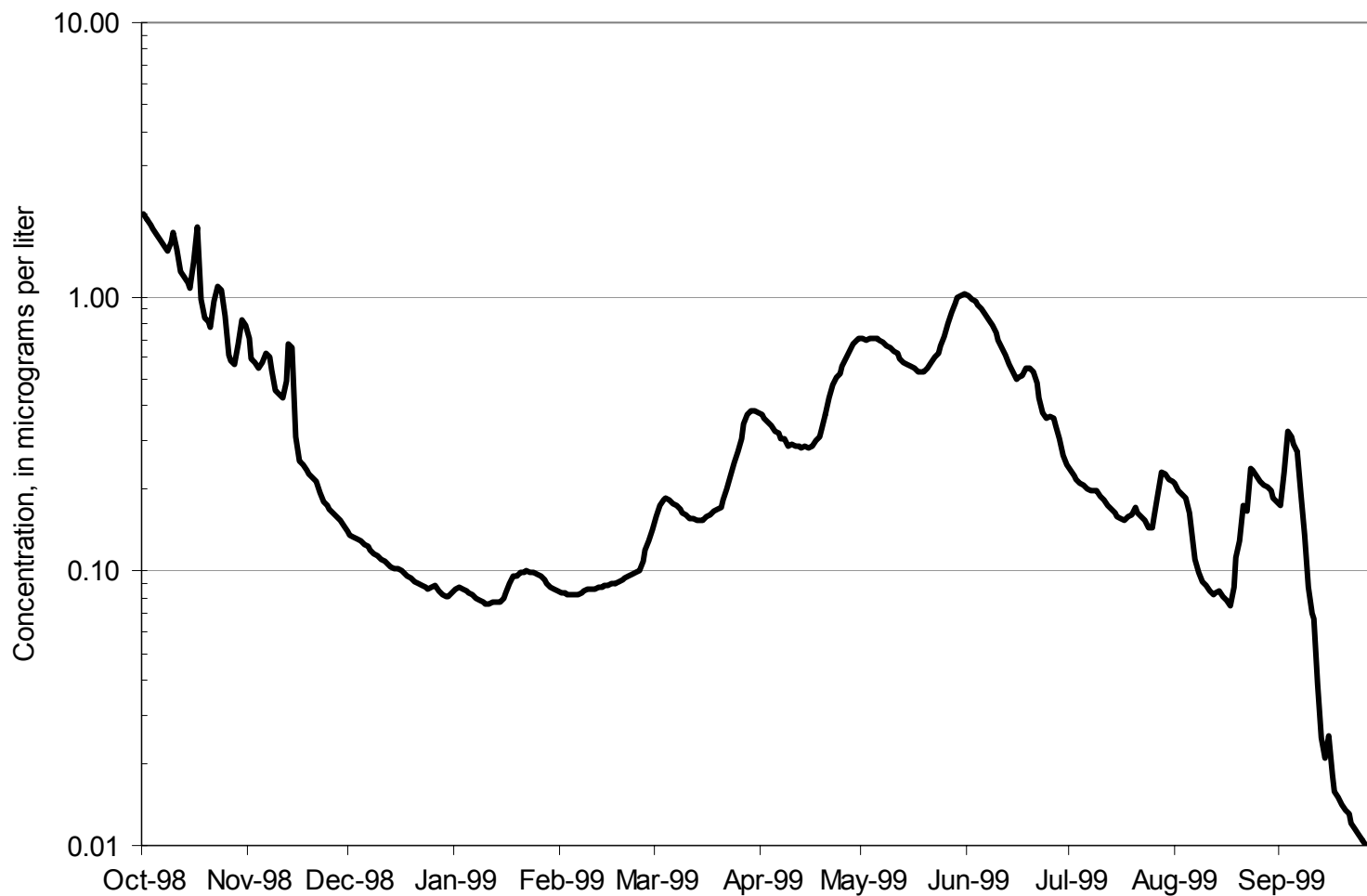


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Coeur d'Alene Basin RI/FS  
RI REPORT

Doc Control:4162500.6615.05.a  
Generation: 1

CDA Lake Series  
5/24/01

**Figure 5.6.2-5**  
**Daily Concentrations of Dissolved Lead at Coeur d'Alene River**  
**Near Harrison, ID, 1999 Water Year**



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Coeur d'Alene Basin RI/FS  
RI REPORT

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Generation: 1

CDA Lake Series  
5/24/01

**Figure 5.6.2-6**  
**Daily Concentrations of Dissolved Lead at Spokane River**  
**Near Post Falls, ID, 1999 Water Year**

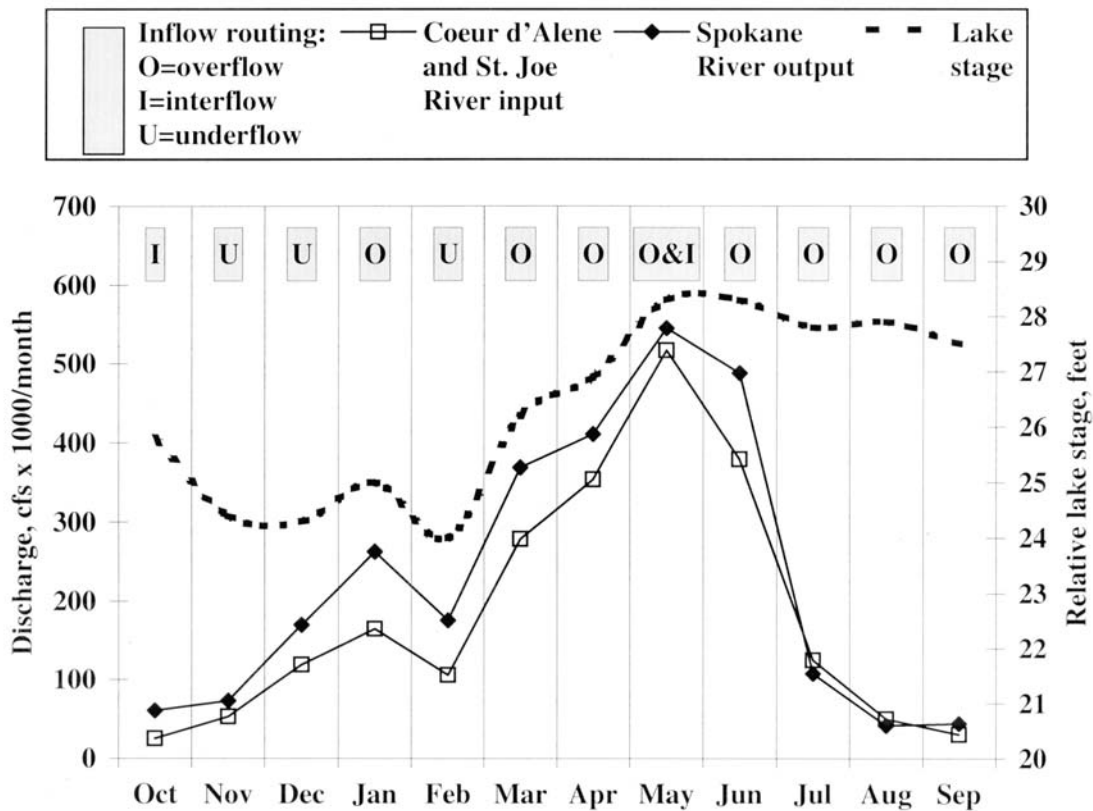
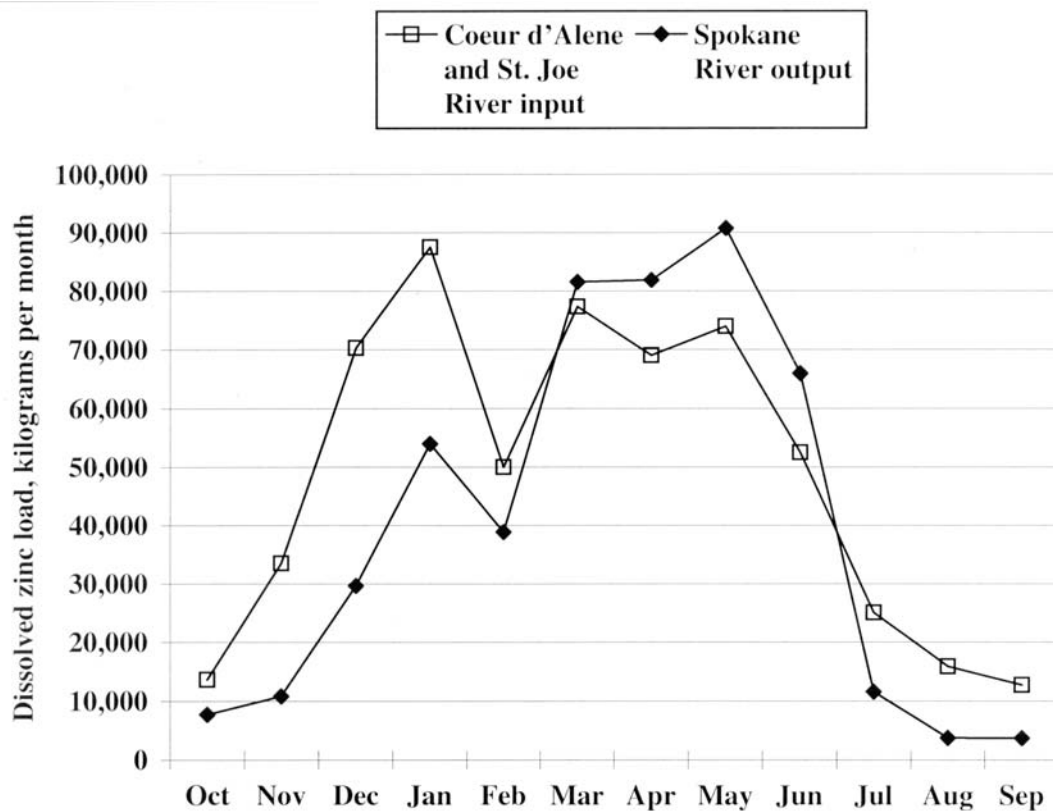


Figure 5.6.2-7  
Monthly Values for Dissolved Zinc Loads, Discharge, Lake Stage, and Inflow Routing, Coeur d'Alene Lake, 1999 Water Year

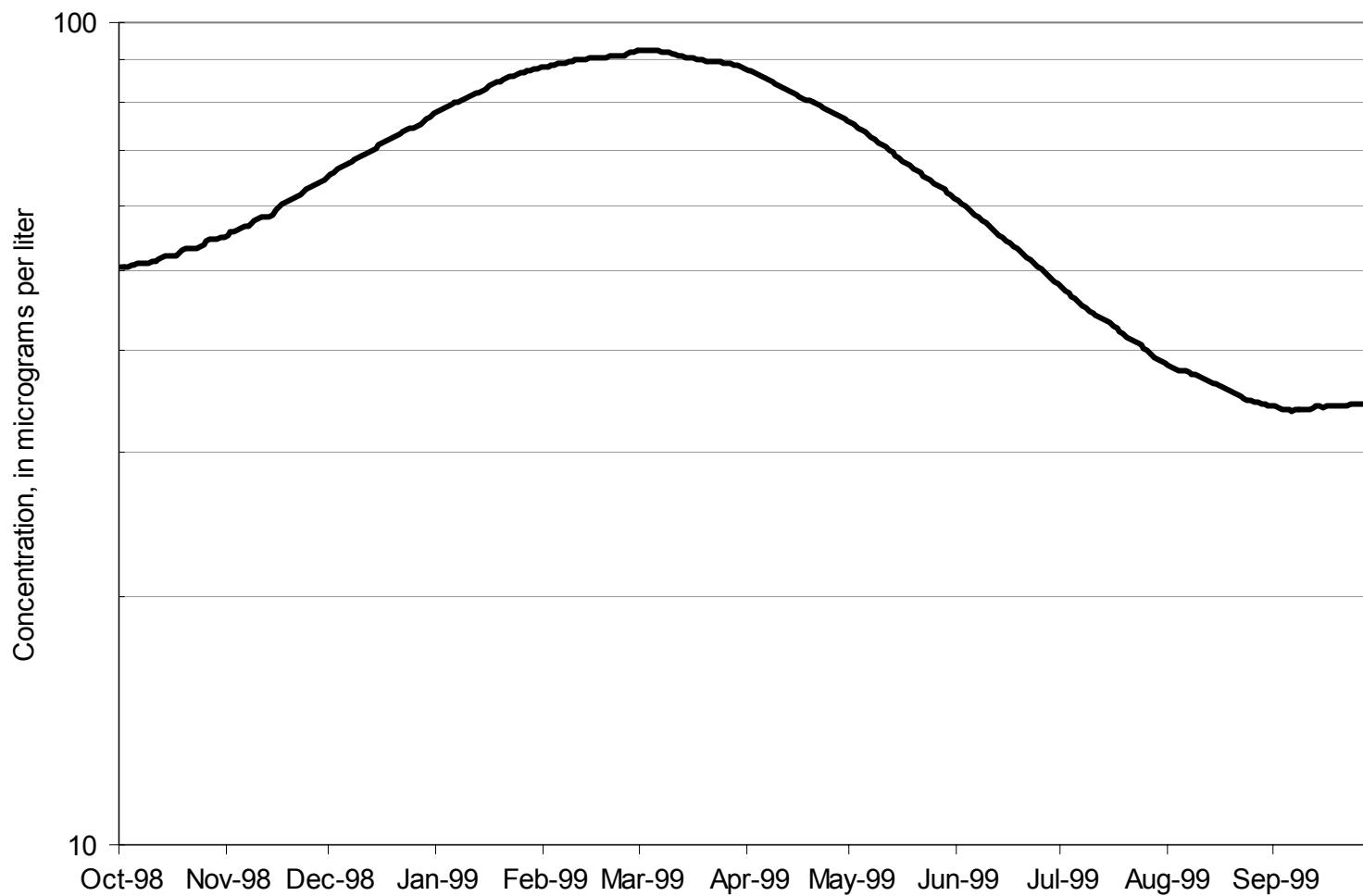


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**Figure 5.6.2-8**  
**Daily Concentrations of Dissolved Zinc at Coeur d'Alene River**  
**Near Harrison, ID, 1999 Water Year**



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**Figure 5.6.2-9**  
**Daily Concentrations of Dissolved Zinc at Spokane River**  
**Near Post Falls, ID, 1999 Water Year**

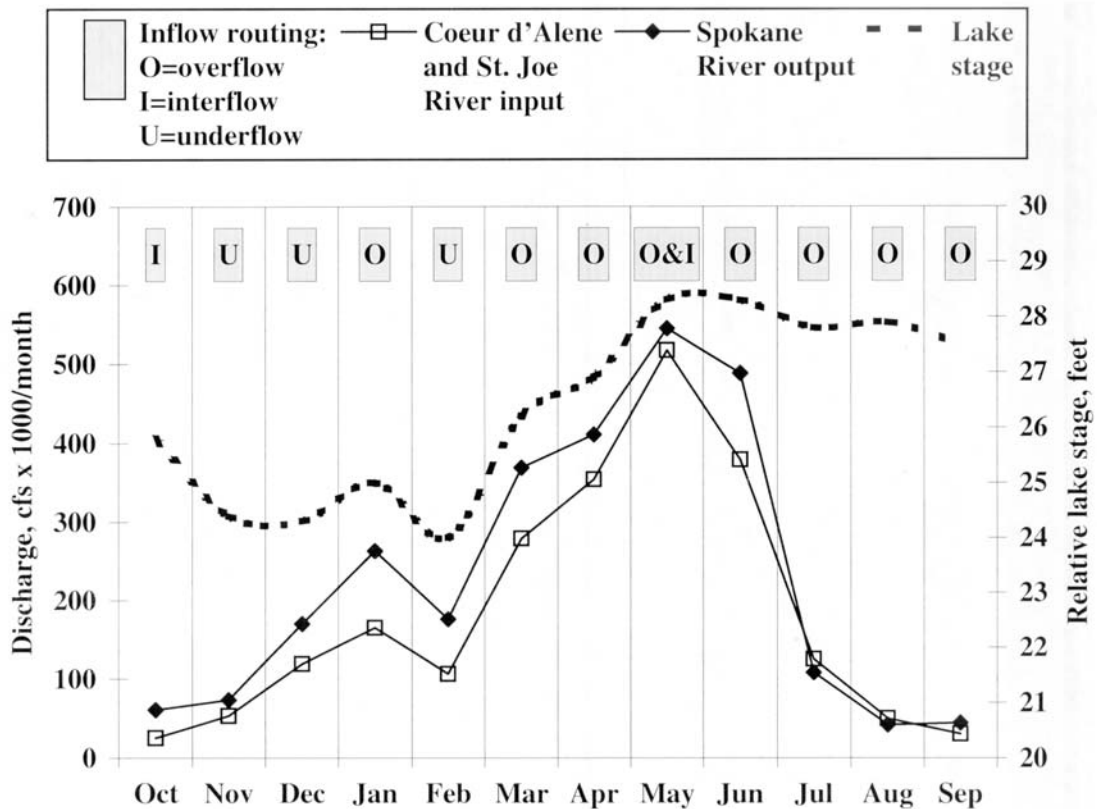
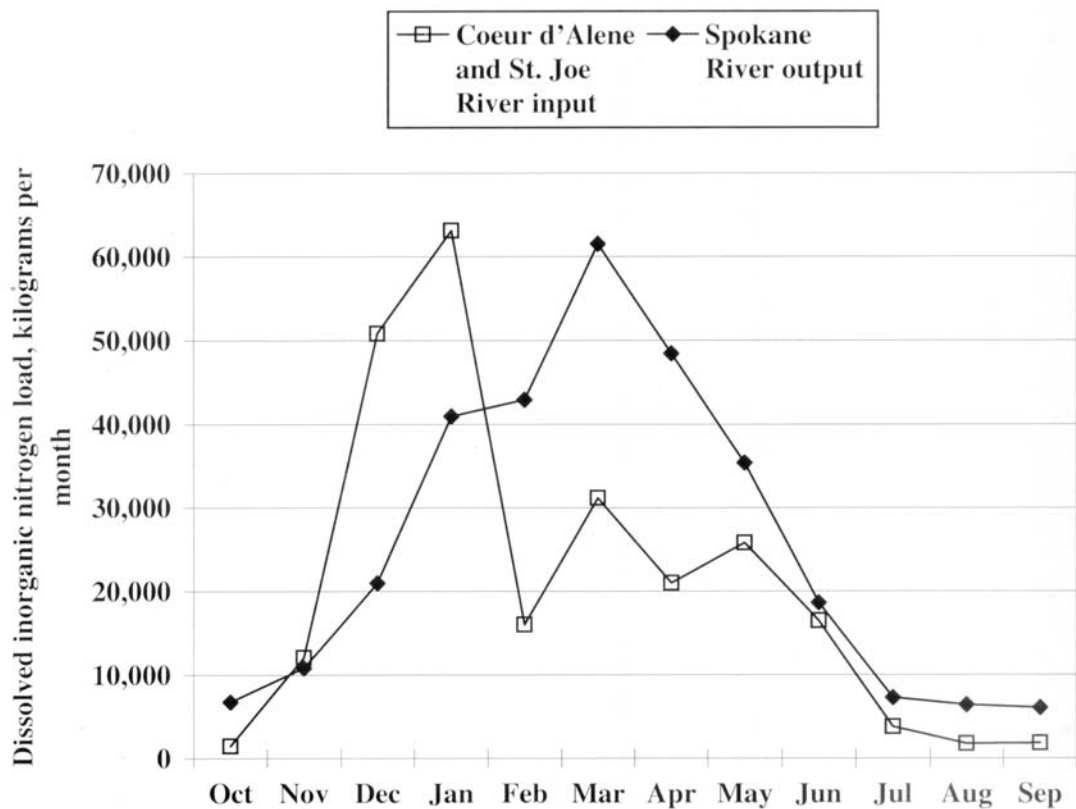
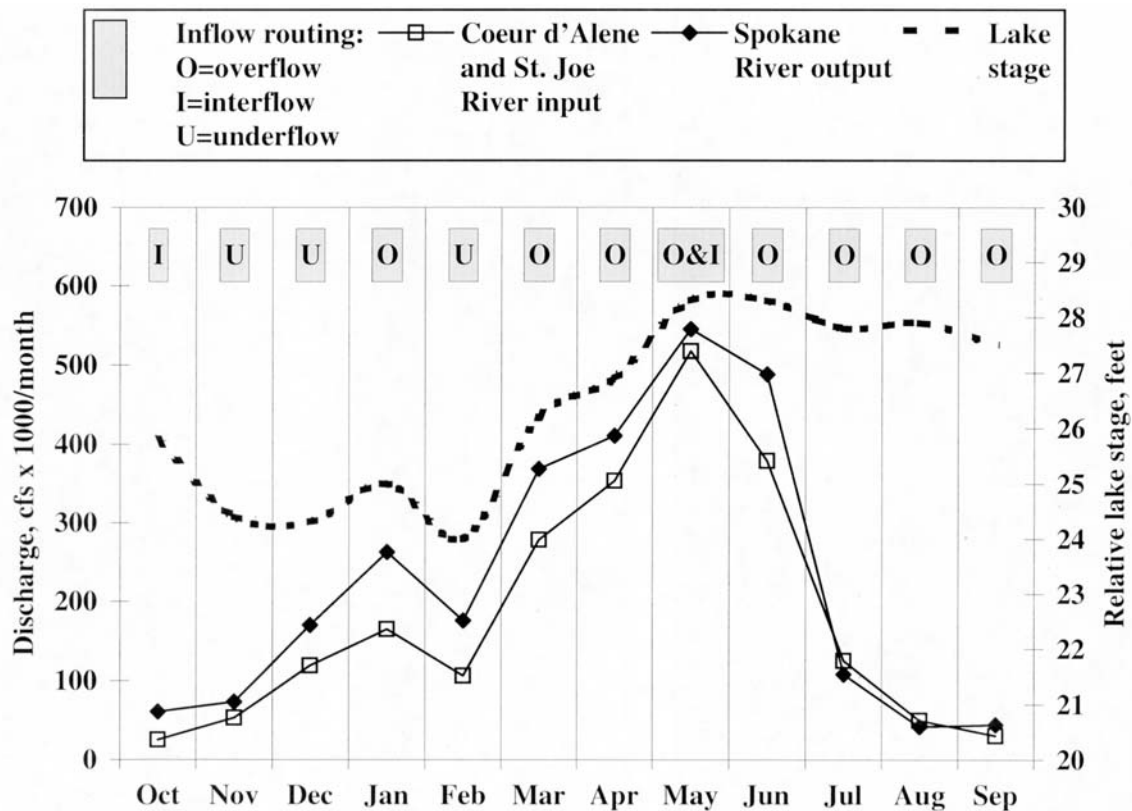
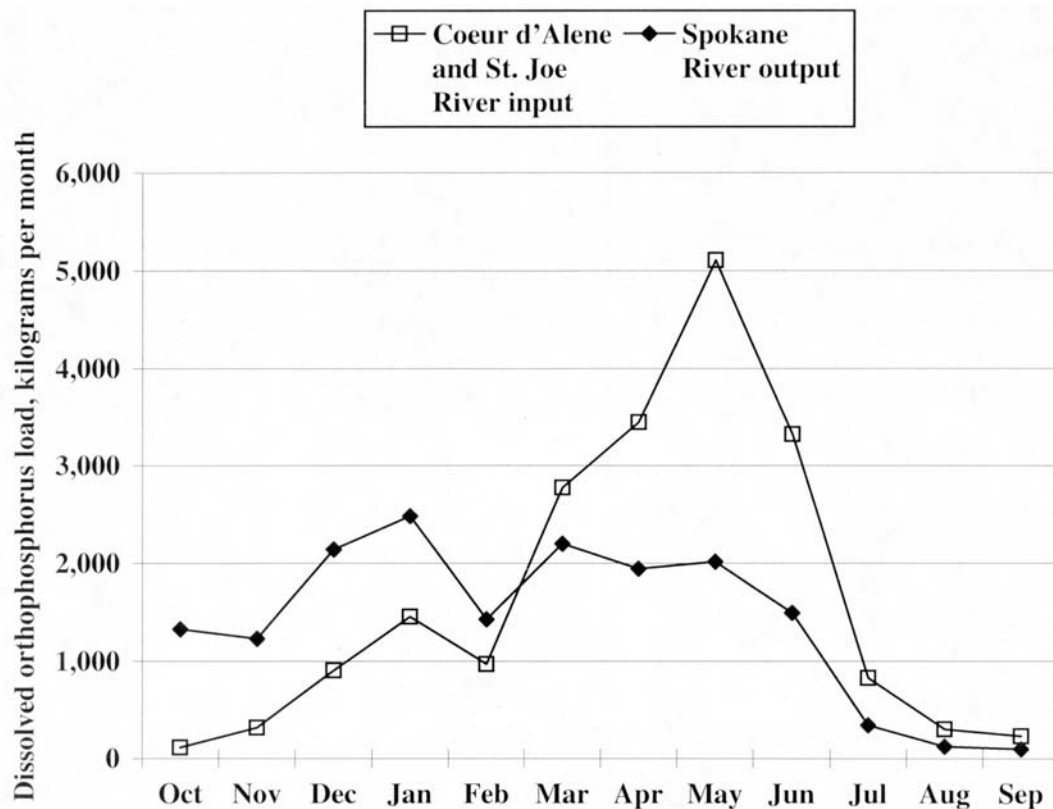
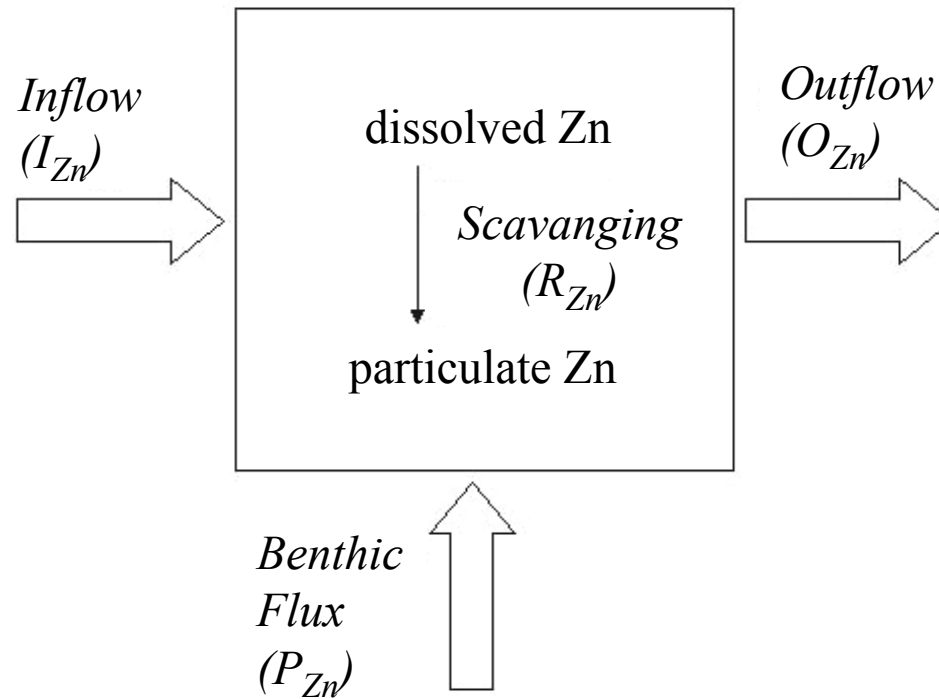
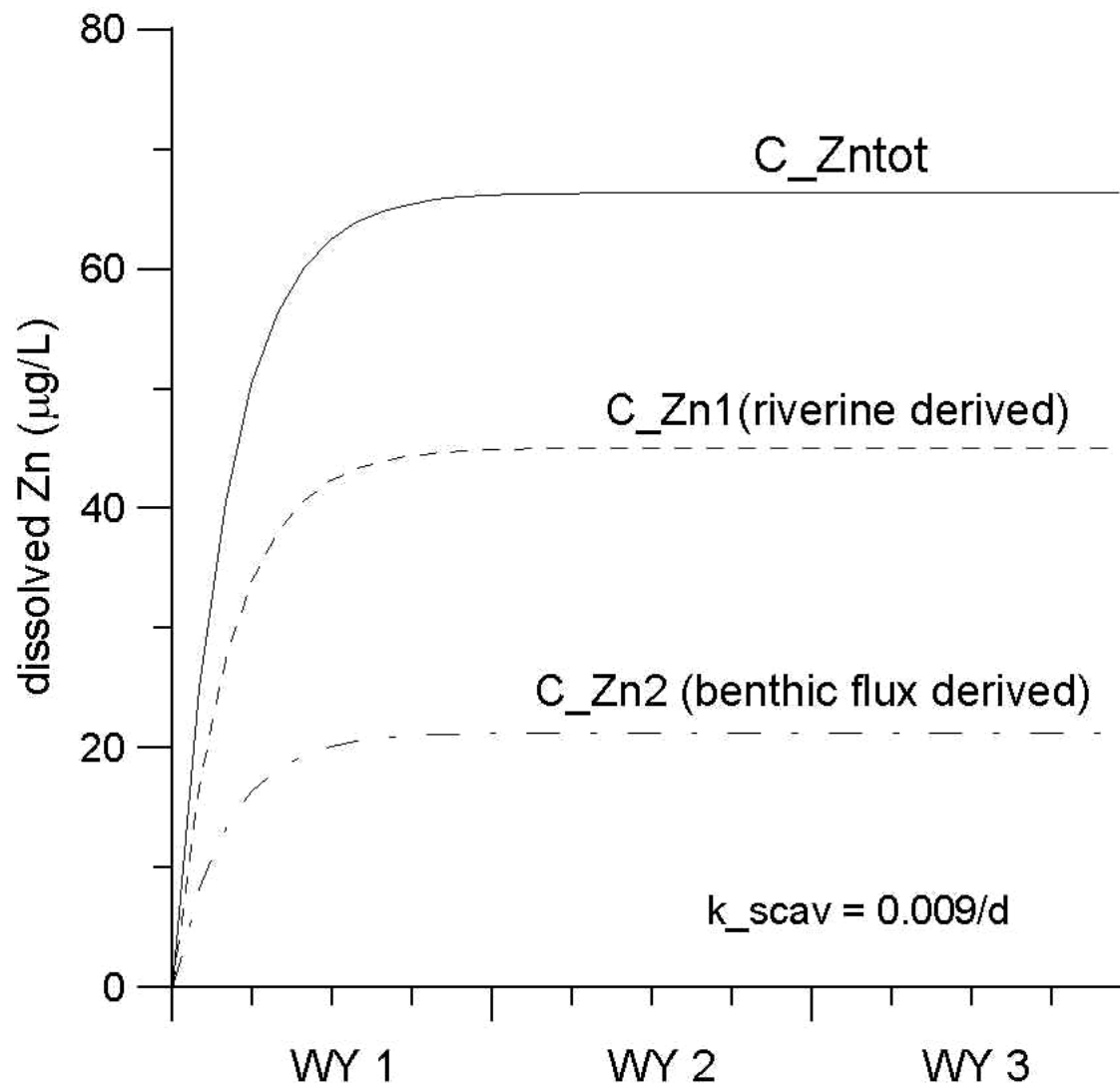
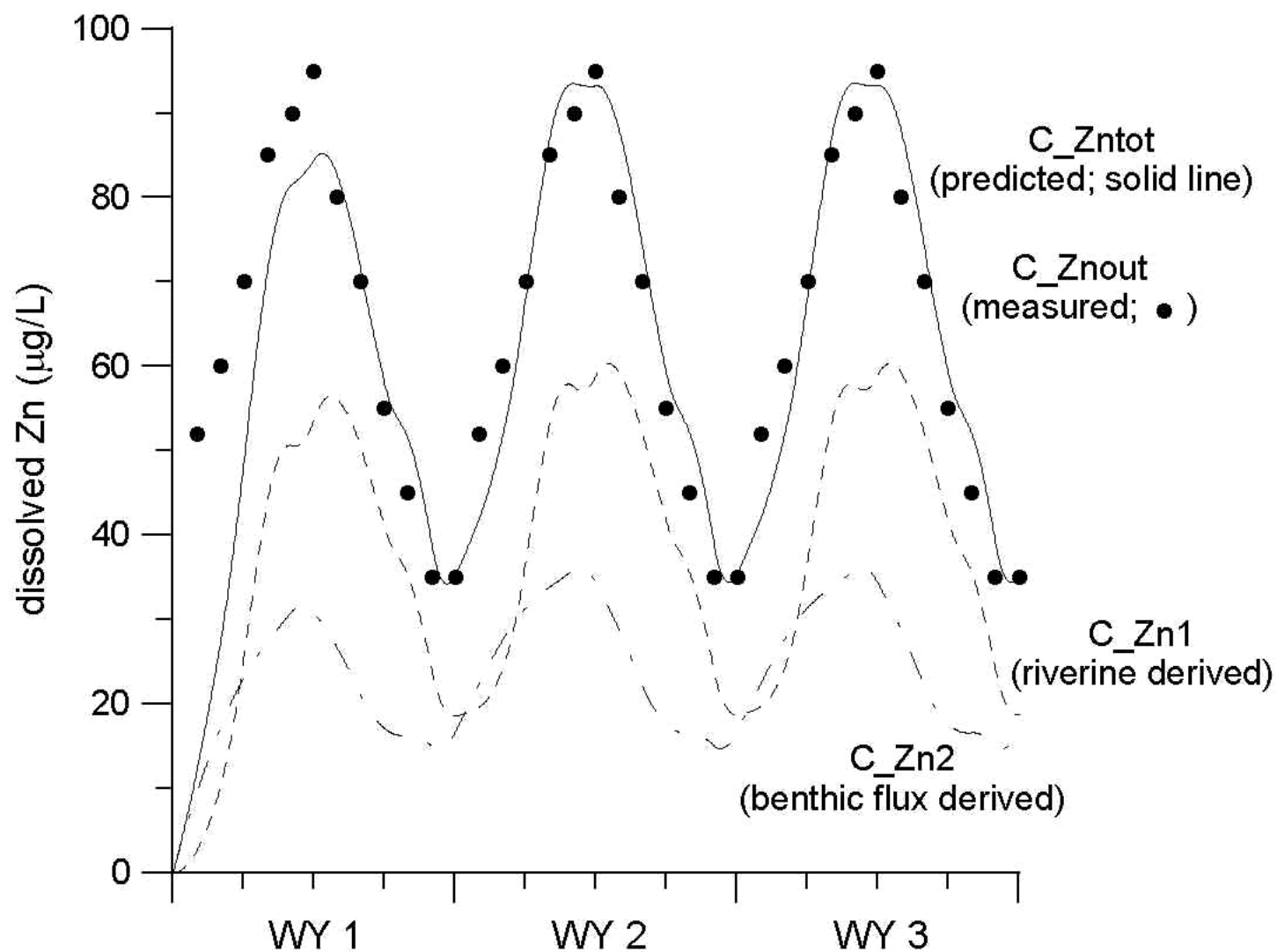


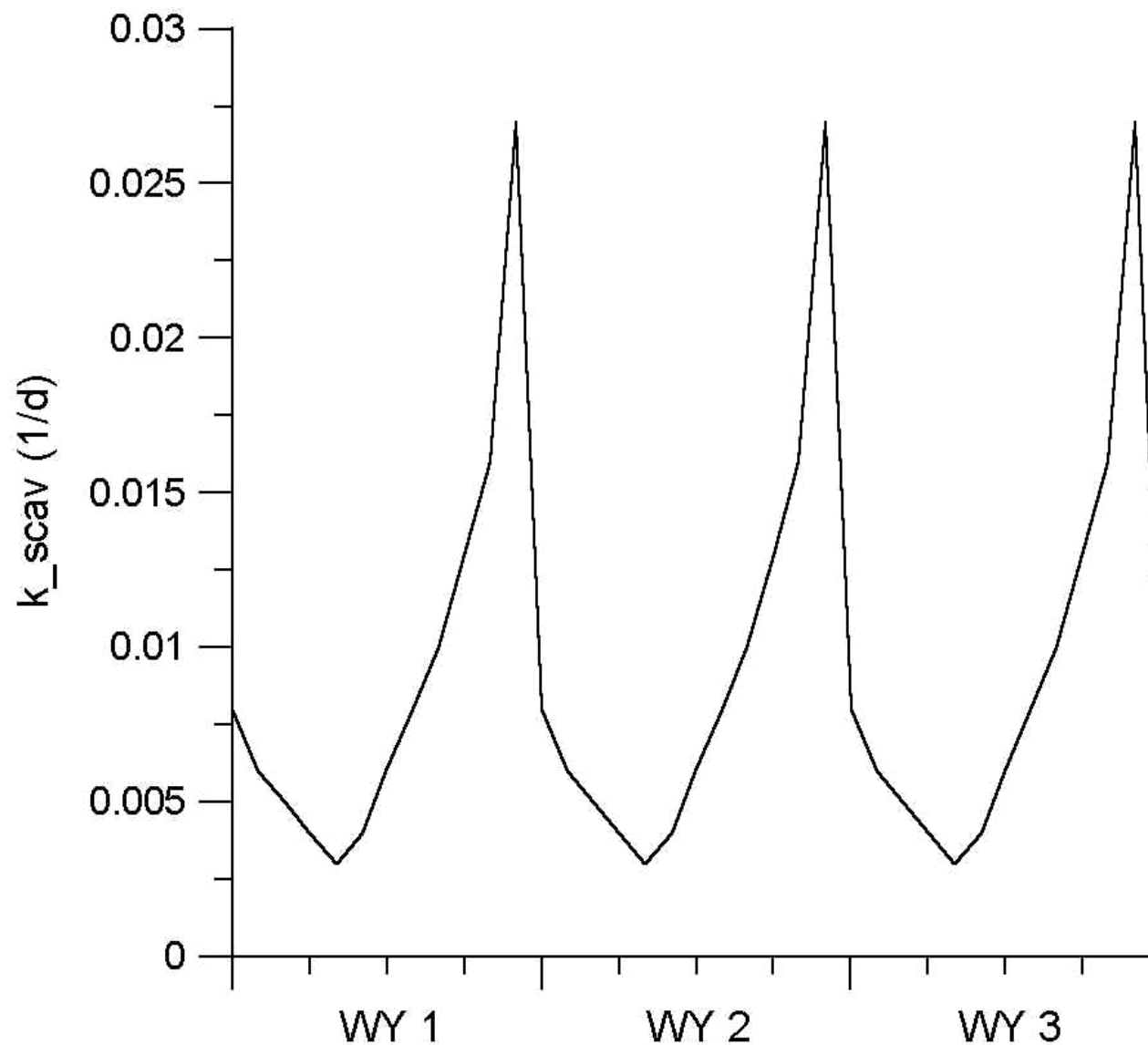
Figure 5.6.2-10  
Monthly Values for Dissolved Nitrogen Loads, Discharge, Lake Stage, and Inflow Routing, Coeur d'Alene Lake, 1999 Water Year

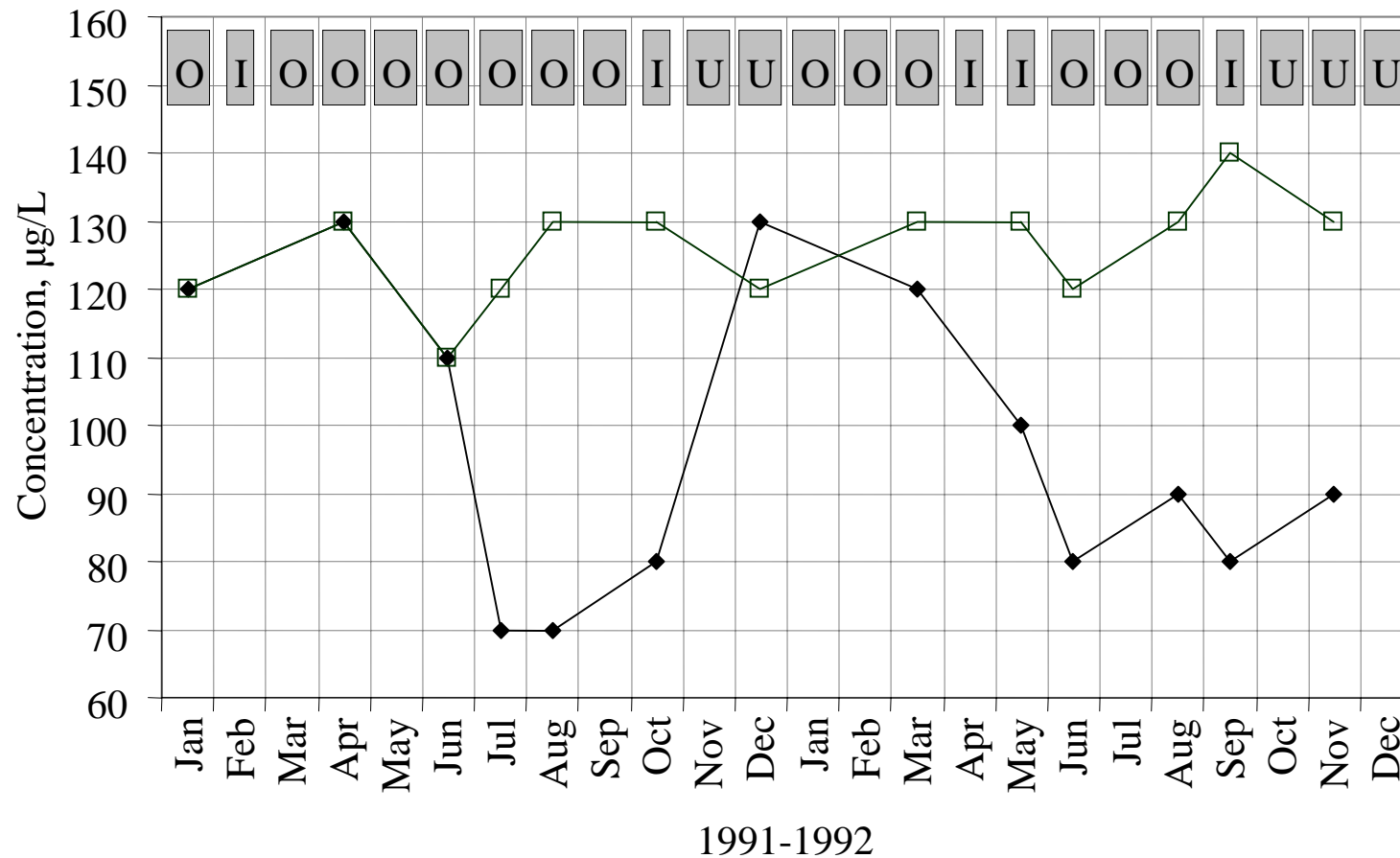
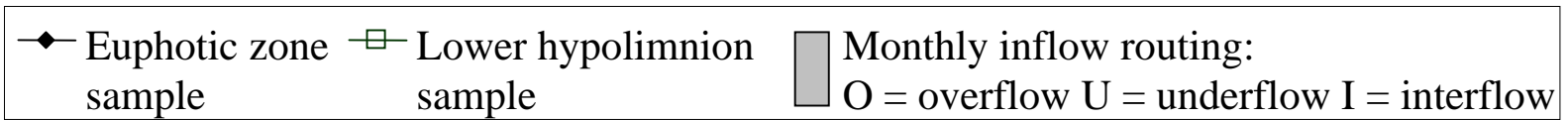












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Figure 5.6.3-5  
 Concentration of Whole-Water Recoverable Zinc in Euphotic Zone and Lower  
 Hypolimnion And Monthly Inflow Routing, Station C3 (Driftwood  
 Point Station), Coeur d'Alene Lake, 1991-92

**Table 5.1-1**  
**Inflow, Outflow, and Residual Loads of Cadmium, Lead, and Zinc for**  
**Coeur d'Alene Lake During Water Years 1992-97 and 1999**

Constituent and Year	Annual Mean Discharge (cfs)	Whole-water recoverable load (kg/yr)				Dissolved load (kg/yr)			
		Inflow	Outflow	Residual <sup>a</sup>	(Residual÷Inflow) x 100	Inflow	Outflow	Residual <sup>a</sup>	(Residual÷Inflow) x 100
Cadmium									
1992	3,460	4,020	1,960	2,060	51	2,370	2,090	280	12
1993	5,330	5,610	3,020	2,590	46	3,120	3,220	-100	-3
1994	2,970	3,810	1,690	2,120	56	2,220	1,800	420	19
1995	6,300	7,230	3,570	3,660	51	3,570	3,810	-240	-7
1996	10,200	14,100	5,790	8,310	59	4,960	6,200	-1,240	-25
1997	10,300	11,000	5,830	5,170	47	4,480	6,240	-1,760	-39
1999	7,530	5,000	2,200	2,800	56	3,900	1,680	2,220	57
Lead									
1992	3,460	62,900	17,600	45,300	72	9,000	3,160	5,840	65
1993	5,330	340,000	37,600	302,000	89	15,900	5,910	9,990	63
1994	2,970	87,800	16,100	71,700	82	8,890	2,640	6,250	70
1995	6,300	472,000	37,000	435,000	92	24,500	7,040	17,500	71
1996	10,200	1,840,000	81,600	1,760,000	96	81,000	13,100	68,000	84
1997	10,300	1,330,000	100,000	1,230,000	92	55,300	13,700	41,600	75
1999	7,530	268,000	23,000	245,000	91	18,300	2,800	15,500	85
Zinc									
1992	3,460	485,000	321,000	164,000	34	484,000	272,000	212,000	43
1993	5,330	660,000	455,000	205,000	31	631,000	394,000	237,000	38
1994	2,970	458,000	263,000	195,000	43	453,000	225,000	228,000	50
1995	6,300	883,000	578,000	305,000	35	722,000	491,000	231,000	32
1996	10,200	1,860,000	890,000	970,000	52	996,000	767,000	229,000	23
1997	10,300	1,450,000	862,000	588,000	41	901,000	752,000	149,000	17
1999	7,530	716,000	490,000	226,000	32	580,000	480,000	100,000	17

**Table 5.1-1 (Continued)**  
**Inflow, Outflow, and Residual Loads of Cadmium, Lead, and Zinc for**  
**Coeur d'Alene Lake During Water Years 1992-97 and 1999**

<sup>a</sup>Inflow-outflow

<sup>b</sup> 38 of 50 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

<sup>c</sup> 1 of 10 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

<sup>d</sup> 16 of 21 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

<sup>e</sup> 2 of 49 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

<sup>f</sup> 1 of 10 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

<sup>g</sup> 13 of 21 concentrations reported as <1 µg/L, assigned value of 0.5 µg/L in load model for 1992-97.

**Table 5.1-2**  
**Inflow, Outflow, and Residual Loads of Nitrogen and Phosphorus for Coeur d'Alene Lake**  
**During Calendar Years 1991-92 and Water Year 1999**

Constituent and Year	Annual Mean Discharge <sup>a</sup> (cfs)	Load (kg/yr)			(Residual÷Inflow) x 100
		Inflow	Outflow	Residual <sup>b</sup>	
Total Nitrogen					
1991	7,020	2,270,000	2,150,000	120,000	5
1992	3,500	1,020,000	935,000	85,000	8
1999	7,530	857,000	1,100,000	-243,000	-28
Total Phosphorus					
1991	7,020	133,000	54,000	79,000	59
1992	3,500	55,000	39,000	16,000	29
1999	7,530	115,000	85,000	30,000	26
Dissolved Inorganic Nitrogen					
1991	7,020	333,000	391,000	-58,000	-17
1992	3,500	146,000	184,000	-38,000	-26
1999	7,530	232,000	306,000	-74,000	-32
Dissolved Orthophosphorus					
1991	7,020	24,000	14,000	10,000	42
1992	3,500	11,100	11,000	100	1
1999	7,530	16,300	16,800	-500	-3

<sup>a</sup> Measured at USGS station 12419000, Spokane River near Post Falls, Idaho

<sup>b</sup> Inflow - outflow

**Table 5.2-1**  
**Hydraulic-Residence Time<sup>a,b</sup> for Coeur d'Alene Lake**

Time Period	Annual Value (years)	Monthly discharge extremes (years)	
		Minimum Discharge	Maximum Discharge
Period of record <sup>c</sup>	0.51	3.3 (August)	0.18 (May)
Calendar year 1991	0.45	3.2 (August)	0.18 (May)
Calendar year 1992	0.91	5.2 (August)	0.36 (March)
Water year 1999	0.42	2.4 (August)	0.18 (March)

<sup>a</sup>Lake volume divided by outflow volume

<sup>b</sup>Outflow volume measured at USGS gaging station 12419000, Spokane River near Post Falls, Idaho

<sup>c</sup>October, 1912 - September 1999

**Table 5.2-2**  
**Inflow Plume Routing in Coeur d'Alene Lake Based on Comparison of Riverine Inflow Temperatures**  
**and Water Column Temperature Range at Station C3 (Driftwood Point) for Calendar Years**  
**1991 and 1992 and Water Year 1999**

Date of River Temperature	Water Temperature (°C) and Instantaneous Discharge (cfs)				Date and Range of Water Temperature at Lake Station C3 <sup>c</sup> (°C)		Inflow Plume Routing		
	Coeur d'Alene River <sup>a</sup>		St. Joe River <sup>b</sup>				Overflow	Interflow	Underflow
1991									
1/3	0.0	1,610	0.0	1,310	–	–	•	•	
1/22	1.0	2,380	0.0	2,410	1/15	1.9 - 3.1	•	•	
2/12	3.0	4,710	1.0	3,900	–	–	•	•	
2/26	4.5	8,410	5.0	6,870	–	–			•
3/25	5.0	3,100	4.0	3,000	3/11	2.9 - 3.0			•
4/9	5.0	15,400	5.0	8,080	–	–	•		
4/23	7.0	7,600	7.0	9,360	4/17	4.5 - 5.6	•		
5/6	10.0	4,970	9.0	6,770	–	–	•		
5/22	10.0	7,970	9.0	17,200	5/15	5.2 - 8.2	•		
6/4	12.5	4,470	10.0	9,340	6/4	5.7 - 11.8	•		
6/18	15.0	2,690	10.0	5,250	6/26	6.1 - 15.4	•		
7/9	24.0	1,670	18.0	2,910	7/16	6.3 - 20.1	•		
7/31	27.0	655	26.0	1,270	8/5	6.4 - 22.9	•		
8/21	27.0	520	25.0	1,030	8/27	6.3 - 21.6	•		
9/9	20.0	832	18.0	703	9/17	6.5 - 18.6	•	•	
10/2	17.5	473	16.0	472	–	–		•	
10/17	12.0	281	14.0	663	10/7	6.6 - 16.0		•	
10/29	4.5	690	5.5	322	–	–			•
11/13	5.5	370	6.0	861	11/4	7.2 - 9.0			•
11/25	5.5	813	4.0	1,540	–	–			•
12/13	4.0	1,990	4.0	975	12/17	5.2 - 5.7			•

**Table 5.2-2 (Continued)**  
**Inflow Plume Routing in Coeur d'Alene Lake Based on Comparison of Riverine Inflow Temperatures**  
**and Water Column Temperature Range at Station C3 (Driftwood Point) for Calendar Years**  
**1991 and 1992 and Water Year 1999**

Date of River Temperature	Water Temperature (°C) and Instantaneous Discharge (cfs)				Date and Range of Water Temperature at Lake Station C3 <sup>c</sup> (°C)		Inflow Plume Routing		
	Coeur d'Alene River <sup>a</sup>		St. Joe River <sup>b</sup>				Overflow	Interflow	Underflow
1992									
1/6	3.5	751	1	690	–	–	•	•	
2/3	6	4,390	4.5	2,870	1/27	3.7 - 3.8	•		
2/19	6.5	2,830	4.5	5,480	–	–	•		
3/5	6	5,240	8	4,620	3/9	4.2 - 6.3	•		
3/20	13	4,030	7	4,250	–	–	•		
4/9	7	2,520	5.5	3,230	4/20	5.1 - 8.3		•	
4/29	11.5	2,650	8	5,990	–	–		•	
5/11	12	2,220	9.5	4,190	5/18	6.6 - 13.8		•	
5/26	15	1,480	14.5	3,390	–	–		•	
6/8	21.5	782	19.5	1,320	6/8	6.7 - 18.2	•		
6/22	23	524	22	1,090	6/29	6.8 - 22.1	•		
7/20	22	360	24.5	695	7/20	7.1 - 21.8	•		
8/3	22	85	24	548	8/13	7.0 - 22.0	•		
8/17	24.5	50	25	150	–	–	•		
9/8	17	422	16.5	673	8/31	7.1 - 19.2		•	
10/6	5	202	–	–	9/22	7.4 - 16.2			•
10/20	5	507	11	567	10/10	7.6 - 13.6			•
11/17	5	776	6	1,000	11/9	7.6 - 10.0			•
12/9	1	704	2	769	12/14	5.6 - 5.7			•

**Table 5.2-2 (Continued)**  
**Inflow Plume Routing in Coeur d'Alene Lake Based on Comparison of Riverine Inflow Temperatures**  
**and Water Column Temperature Range at Station C3 (Driftwood Point) for Calendar Years**  
**1991 and 1992 and Water Year 1999**

Date of River Temperature	Water Temperature (°C) and Instantaneous Discharge (cfs)				Date and Range of Water Temperature at Lake Station C3 c (°C)		Inflow Plume Routing		
	Coeur d'Alene River <sup>a</sup>	St. Joe River <sup>b</sup>					Overflow	Interflow	Underflow
1999 Water Year									
10/23	9	–	–	–	–	–			
11/16	7.5	1,100	–	–	–	–			
12/14	4	2,440	–	–	–	–			
3/23	6.5	7,850	–	–	–	–			
4/21	6.5	10,700	–	–	–	–			
5/6	7.5	8,320	–	–	–	–			
5/27	10	12,400	–	–	6/2	6.1 - 11.4		•	
6/17	13.5	6,150	–	–	–	–			
7/14	19	1,890	–	–	7/29	6.9 - 19.9	•	•	
8/11	22	627	–	–	8/30	7.2 - 20.7	•		
9/9	22	362	–	–	9/21	7.3 - 18.3	•		

<sup>a</sup> Coeur d'Alene River near Harrison, ID (USGS station 12413860)

<sup>b</sup> St. Joe River at St. Maries, ID (USGS station 12415075)

<sup>c</sup> Coeur d'Alene Lake 1.7 mile NE of University Point near Harrison, ID (USGS station 473054116500600)

Notes:

– - not sampled or evaluated

°C - degrees Celsius

cfs - cubic feet per second

• - Indicates type of Inflow Plume Routing observed

**Table 5.2-3**  
**Water-Quality Characteristics at Eight Stations on Coeur d'Alene Lake During the 1999 Spring Snowmelt-Runoff Event:**  
**Samples Collected June 2-3 From Inflow Plume Overlaying Lake Water**

Inflow Plume Variables and Units	Station Number, Station Name, Latitude/Longitude, Total Station Depth in Meters							
	L. CR Coeur d'Alene River at Mouth 4727301164759 3 Meters	L. SJR St. Joe River at Mouth 4722351164502 5 Meters	L. 5 Coeur d'Alene Lake NE of Blue Point 4725001164500 17 Meters	L. 4 Coeur d'Alene Lake NE of University Point 4730541165006 38 Meters	L. 3 Coeur d'Alene Lake SW of Driftwood Point 4735001164820 54 Meters	L. 1 Coeur d'Alene Lake SE of Tubbs Hill 4739001164530 44 Meters	L. 2 Coeur d'Alene Lake at Wolf Lodge Bay 4737301164100 34 Meters	L. SR Coeur d'Alene Lake Outlet 4740301164806 4 Meters
Depth range, meters	0 - 3	0 - 5	0 - 13	0 - 10	0 - 9	0 - 13	0 - 5	0 - 4
Temperature range, degrees Celsius	9.2 - 9.1	9.0 - 8.6	12.7 - 9.0	11.4 - 10.0	11.9 - 11.8	11.4 - 11.2	13.3 - 12.0	11.7 - 11.5
Specific conductance range, microsiemens	37 - 37	30 - 30.2	30 - 32	34 - 38	38 - 39	40 - 42	43 - 44	42 - 42
Light transmission, range, percent	44 - 45	38 - 39	36 - 40	41 - 42	47 - 48	51 - 52	56 - 58	53 - 54
<b>Constituent Concentrations, Micrograms per Liter</b>								
Nitrogen, total	160	147	157	129	136	157	182	155
Inorganic nitrogen, dissolved	25	31	20	21	13	16	12	16
Phosphorus, total	10	12	12	9	9	7	8	8
Orthophosphorus, dissolved	1	2	1	1	1	1	<1	<1
Cadmium, WWR	0.71	<0.1	<0.1	0.30	0.33	0.33	0.29	0.36
Cadmium, dissolved	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead, WWR	30.7	0.18	2.9	11.8	13.1	10.6	2.8	10.5
Lead, dissolved	4.5	<1.0	<1.0	1.6	1.3	1.3	<1.0	1.2
Zinc, WWR	96.2	2.8	11.9	44.2	50.1	54.3	58.4	62.3
Zinc, dissolved	96.6	2.7	10.0	42.5	49.5	53.3	54.0	54.4

Notes:

< - less than

WWR - whole-water recoverable

**Table 5.2-4**  
**Water-Quality Characteristics at Eight Stations on Coeur d'Alene Lake During the 1999 Spring Snowmelt-Runoff Event:**  
**Samples Collected June 2-3 From the Transition Zone Between the Inflow Plume and Underlying Lake Water**

Transition Zone Variables and Units	Station Number, Station Name, Latitude/Longitude, Total Station Depth in Meters							
	L. CR Coeur d'Alene River at mouth 4727301164759 3 Meters	L. SJR St. Joe River at Mouth 4722351164502 5 Meters	L. 5 Coeur d'Alene Lake NE of Blue Point 4725001164500 17 Meters	L. 4 Coeur d'Alene Lake NE of University Point 4730541165006 38 Meters	L. 3 Coeur d'Alene Lake SW of Driftwood Point 4735001164820 54 Meters	L. 1 Coeur d'Alene Lake SE of Tubbs Hill 4739001164530 44 Meters	L. 2 Coeur d'Alene Lake at Wolf Lodge Bay 4737301164100 34 Meters	L. SR Coeur d'Alene Lake Outlet 4740301164806 4 Meters
Depth range, meters	NA	NA	13 - 17	10 - 20	9 - 34	13 - 23	5 - 15	NA
Temperature range, degrees Celsius	NA	NA	9.0 - 7.1	10.0 - 7.9	11.8 - 7.2	11.2 - 8.0	12.0 - 11.0	NA
Specific conductance range, microsiemens	NA	NA	32 - 48	38 - 48	39 - 48	42 - 48	44 - 45	NA
Light transmission, range, percent	NA	NA	40 - 56	42 - 63	48 - 66	52 - 65	58 - 60	NA
<b>Constituent Concentrations, Micrograms per Liter</b>								
Nitrogen, total	NA	NA	170	NS	NS	NS	NS	NA
Inorganic nitrogen, dissolved	NA	NA	44	NS	NS	NS	NS	NA
Phosphorus, total	NA	NA	11	NS	NS	NS	NS	NA
Orthophosphorus, dissolved	NA	NA	2	NS	NS	NS	NS	NA
Cadmium, WWR	NA	NA	0.20	NS	NS	NS	NS	NA
Cadmium, dissolved	NA	NA	<1.0	NS	NS	NS	NS	NA

**Table 5.2-4 (Continued)**  
**Water-Quality Characteristics at Eight Stations on Coeur d'Alene Lake During the 1999 Spring Snowmelt-Runoff Event:**  
**Samples Collected June 2-3 From the Transition Zone Between the Inflow Plume and Underlying Lake Water**

Transition Zone Variables and Units	Station Name, Latitude/Longitude, Total Station Depth in Meters							
	L. CR Coeur d'Alene River at mouth 4727301164759 3 Meters	L. SJR St. Joe River at Mouth 4722351164502 5 Meters	L. 5 Coeur d'Alene Lake NE of Blue Point 4725001164500 17 Meters	L. 4 Coeur d'Alene Lake NE of University Point 4730541165006 38 Meters	L. 3 Coeur d'Alene Lake SW of Driftwood Point 4735001164820 54 Meters	L. 1 Coeur d'Alene Lake SE of Tubbs Hill 4739001164530 44 Meters	L. 2 Coeur d'Alene Lake at Wolf Lodge Bay 4737301164100 34 Meters	L. SR Coeur d'Alene Lake Outlet 4740301164806 4 Meters
Lead, WWR	NA	NA	2.4	NS	NS	NS	NS	NA
Lead, dissolved	NA	NA	<1.0	NS	NS	NS	NS	NA
Zinc, WWR	NA	NA	42.1	NS	NS	NS	NS	NA
Zinc, dissolved	NA	NA	41.8	NS	NS	NS	NS	NA

Notes:

< - less than

NA - not applicable

NS - not sampled

WWR - whole water recoverable

**Table 5.2-5**  
**Water-Quality Characteristics at Eight Stations on Coeur d'Alene Lake During the 1999 Spring Snowmelt-Runoff Event:**  
**Sample Collected June 2-3 From Lake Water Underlying Inflow Plume**

Lake Water Variables and Units	Station Number, Station Name, Latitude/Longitude, Total Station Depth in Meters							
	L. CR Coeur d'Alene River at Mouth 4727301164759 3 Meters	L. SJR St. Joe River at Mouth 4722351164502 5 Meters	L. 5 Coeur d'Alene Lake NE of Blue Point 4725001164500 17 Meters	L. 4 Coeur d'Alene Lake NE of University Point 4730541165006 38 Meters	L. 3 Coeur d'Alene Lake SW of Driftwood Point 4735001164820 54 Meters	L. 1 Coeur d'Alene Lake SE of Tubbs Hill 4739001164530 44 Meters	L. 2 Coeur d'Alene Lake at Wolf Lodge Bay 4737301164100 34 Meters	L. SR Coeur d'Alene Lake Outlet 4740301164806 4 Meters
Depth range, meters	NA	NA	NA	20 - 38	34 - 54	23 - 44	15 - 34	NA
Temperature range, degrees Celsius	NA	NA	NA	7.9 - 6.3	7.2 - 6.5	8.0 - 6.2	11.0 - 6.8	NA
Specific conductance range, microsiemens	NA	NA	NA	48 - 52	48 - 52	48 - 52	45 - 53	NA
Light transmission, range, percent	NA	NA	NA	63 - 67	66 - 68	65 - 67	60 - 67	NA
<b>Constituent concentrations, micrograms per liter</b>								
Nitrogen, total	NA	NA	NA	299	230	251	237	NA
Inorganic nitrogen, dissolved	NA	NA	NA	87	87	95	71	NA
Phosphorus, total	NA	NA	NA	11	9	10	8	NA
Orthophosphorus, dissolved	NA	NA	NA	2	2	2	<1	NA
Cadmium, WWR	NA	NA	NA	0.44	0.39	0.40	0.34	NA
Cadmium, dissolved	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	NA

**Table 5.2-5 (Continued)**  
**Water-Quality Characteristics at Eight Stations on Coeur d'Alene Lake During the 1999 Spring Snowmelt-Runoff Event:**  
**Sample Collected June 2-3 From Lake Water Underlying Inflow Plume**

Lake Water Variables and Units	Station Number, Station Name, Latitude/Longitude, Total Station Depth in Meters							
	L. CR Coeur d'Alene River at Mouth 4727301164759 3 Meters	L. SJR St. Joe River at Mouth 4722351164502 5 Meters	L. 5 Coeur d'Alene Lake NE of Blue Point 4725001164500 17 Meters	L. 4 Coeur d'Alene Lake NE of University Point 4730541165006 38 Meters	L. 3 Coeur d'Alene Lake SW of Driftwood Point 4735001164820 54 Meters	L. 1 Coeur d'Alene Lake SE of Tubbs Hill 4739001164530 44 Meters	L. 2 Coeur d'Alene Lake at Wolf Lodge Bay 4737301164100 34 Meters	L. SR Coeur d'Alene Lake Outlet 4740301164806 4 Meters
Lead, WWR	NA	NA	NA	6.1	3.9	3.7	2.3	NA
Lead, dissolved	NA	NA	NA	<1.0	<1.0	<1.0	<1.0	NA
Zinc, WWR	NA	NA	NA	85.6	82.7	84.0	76.6	NA
Zinc, dissolved	NA	NA	NA	88.3	86	90.1	78.3	NA

Notes:

NA - not applicable

NS - not sampled

< - less than

WWR - whole-water recoverable

**Table 5.3-1**  
**Sedimentation Rates at 12 Locations in Coeur d'Alene Lake**

Core Number and Approximate Location <sup>a</sup>	Water Depth (m)	Thickness of Banded Core <sup>b</sup> (cm)	Sedimentation Rate <sup>c</sup> (cm/yr)	Thickness of Layer Above Mt. St. Helens Ash Layer <sup>b</sup> (cm)	Sedimentation Rate Above Ash Layer <sup>d</sup> (cm/yr)
10, Wolf Lodge Bay	30	25	0.31	2.3	0.23
13, Central North arm	35	17	0.21	ND	—
39, Tubbs Hill	40	23.5	0.29	ND	—
47, mid-lake, Mica Bay	40	26	0.33	0.3	0.03
71, mid-lake, Carlin Bay	45	30	0.38	0.5	0.05
93, mid-lake, Powderhorn Bay	40	31	0.39	0.5	0.05
9, Windy Bay	15	34	0.43	3.5	0.35
6, mid-lake, East Point	25	41	0.51	5	0.5
123, mid-lake, Harlow Point	15	119	1.5	20.5	2
7, Coeur d'Alene River delta	10	ND	—	ND	—
8, mid-lake, Blue Point	20	35	0.44	9.6	0.96
146, Chatcolet Lake	10	ND	—	ND	—

<sup>a</sup> Detailed locations listed in Horowitz et al (1995), Table I, Figure 2

<sup>b</sup> Data from Horowitz et al (1995), Table I

<sup>c</sup> Time interval, 1910-1990, based on Horowitz et al (1995)

<sup>d</sup> Time interval, 1980-1990, based on Horowitz et al (1995)

Notes:

— - not measured

cm - centimeters

cm/yr - centimeter per year

m - meters

nd - not detected

**Table 5.3-2**  
**Calculated Estimates of Masses of Cadmium, Lead, and Zinc**  
**Associated With Enriched Sediments in Coeur d'Alene Lake<sup>a</sup>**

<b>Constituent</b>	<b>Total Mass in Enriched Zone (tonnes)</b>	<b>Expected Mass if Sediment Contained Only Background Concentrations (tonnes)</b>	<b>Excess Mass Due to Presence of Enriched Sediments (tonnes)</b>
Cadmium	3,300	16	3,280
Lead	470,000	1,700	468,000
Zinc	240,000	9,600	230,000

<sup>a</sup> Data from Horowitz et al (1995), table III

**Table 5.3-3**  
**Concentrations of Total Phosphorus and Total Nitrogen in Lakebed Sediments at**  
**20 Stations, Coeur d'Alene Lake**

Approximate Station Location	Water Depth (m)	Concentration (mg/kg)	
		Total Phosphorus	Total Nitrogen
Mid-lake, Tubbs Hill	43	1,600	2,900
Wolf Lodge Bay	30	940	2,600
Mid-lake, Driftwood Point	53	1,500	2,600
Mid-lake, University Point	41	1,300	2,000
Mid-lake, Blue Point	18	500	1,100
Chatcolet Lake	11	840	1,700
Between Harlow and Reynolds Points	18	730	1,300
Coeur d'Alene River delta	5	920	1,900
Cave Bay	20	830	1,400
16 to 1 Bay	19	590	1,100
Between East and Rockford Points	32	1,200	1,900
Windy Bay	30	1,000	3,900
Powderhorn Bay	29	900	1,600
Rockford Bay	19	920	860
Carlin Bay	16	920	1,900
Mica Bay	15	1,000	2,200
Squaw Bay	12	610	3,600
Bennett Bay	29	880	2,000
Casco Bay	11	580	3,200
Near Tubbs Hill	29	1,100	2,900

<sup>1</sup> Latitude and longitude reported by Harenberg et al. (1993)

Notes:

m - meters

mg/kg - milligrams per kilogram

**Table 5.5-1**  
**Summary of Three Methods Used to Determine Benthic Fluxes in Coeur d'Alene Lake and**  
**Elements Whose Fluxes Were Determined by Each Method**

Diffusive flux calculations (Balistrieri, 1998)		
<u>Metals</u>	<u>Nutrients</u>	<u>Other Elements</u>
Copper	Silica	Sulfate
Manganese		
Lead		
Zinc		

<i>In-situ</i> benthic flux chamber (Kuwabara et al, 2000)		
<u>Metals</u>	<u>Nutrients</u>	<u>Other Elements</u>
Cadmium	Dissolved Organic Carbon	Bromide
Copper	Ammonia	Oxygen
Iron	Nitrite + Nitrate	Radon
Manganese	Silica	
Lead	Orthophosphorus	
Zinc		

Core incubations (Kuwabara et al, 2000)		
<u>Metals</u>	<u>Nutrients</u>	<u>Other Elements</u>
Cadmium	Ammonia	(none)
Copper	Nitrite + Nitrate	
Iron	Silica	
Mercury	Orthophosphorus	
Methyl-Mercury		
Manganese		
Lead		
Zinc		

**Table 5.5-2**  
**Summary of Benthic Fluxes of Dissolved Metals and Sulfate in Coeur d'Alene Lake**

Station	Method	Benthic flux, <sup>c</sup> micrograms per square centimeter per year								
		Cadmium	Copper	Iron	Mercury	Methyl-Mercury	Manganese	Lead	Zinc	Sulfate
Valhalla <sup>a</sup>	Diffusive flux-peepers	–	-0.22	–	–	–	8.5	0	9.5	7.9
	Diffusive flux-core	–	4.4	–	–	–	853	3.6	451	-26
East Point <sup>a</sup>	Diffusive flux-peepers	–	0.45	–	–	–	73	15	19	-22
	Diffusive flux-core	–	11	–	–	–	1411	15	92	–
Harlow Point <sup>a</sup>	Diffusive flux-peepers	–	0.6	–	–	–	104	6	4.8	-2.9
	Diffusive flux-core	–	1	–	–	–	113	26	92	–
Delta <sup>a</sup>	Diffusive flux-peeper	–	-0.06	–	–	–	17	87	23	-3.2
	Diffusive flux-core	–	-0.06	–	–	–	209	3.6	55	-19
Chatcolet <sup>a</sup>	Diffusive flux-peepers	–	-0.05	–	–	–	-2.5	0	0	–
	Diffusive flux-core	–	3.3	–	–	–	179	0	106	–
Main-channel <sup>b</sup>	<i>In-situ</i> flux chamber	3.1	1.1	175	–	–	3683	2.4	281	–
	Aerated core incubation	1.1	1.4	-10	0.17	0.0006	7444	20.3	-145	–
	Purged core incubation	3.1	2.6	-79	0.34	0.0013	3924	-0.4	-457	–
Mica Bay <sup>b</sup>	<i>In-situ</i> flux chamber	2.3	1.9	114	–	–	3048	1.9	347	–
	Aerated core incubation	-2.9	0.5	16	0.11	0.0003	8182	19.7	-89	–
	Purged core incubation	-3.5	0.5	6.8	0.07	0.0012	8228	9	-390	–

<sup>a</sup> Data from Balistreri (1998)

<sup>b</sup> Data from Kuwabara et al. (2000)

<sup>c</sup> Average flux values were determined for multiple samplings of peepers, flux chambers, and core incubations at each site

Note:

– - no data

**Table 5.5-3**  
**Summary of Benthic Fluxes of Nutrients and Dissolved Organic Carbon in Coeur d'Alene Lake**

Station	Method	Benthic flux, <sup>b</sup> micrograms per square centimeter per year				
		PO <sub>4</sub>	NO <sub>3</sub> + NO <sub>2</sub>	NH <sub>3</sub>	Total N <sup>c</sup>	Dissolved Organic Carbon
Main-channel <sup>a</sup>	<i>In-situ</i> flux chamber	7.2	159	58	217	1942
	Aerated core incubation	91	142	383	526	–
	Purged core incubation	144	58	209	267	–
Mica Bay <sup>a</sup>	<i>In-situ</i> flux chamber	22	210	106	316	399
	Aerated core incubation	46	229	744	973	–
	Purged core incubation	147	-368	709	342	–

<sup>a</sup> Data from Kuwabara et al (2000)

<sup>b</sup> Average flux values were determined for multiple samplings of flux chambers and core incubations at each site

<sup>c</sup> Sum of dissolved NO<sub>2</sub> + NO<sub>3</sub> and dissolved NH<sub>3</sub>

Note:

– - no data

**Table 5.5-4**  
**Comparison of Benthic and Riverine Fluxes of Dissolved Cadmium, Lead, Zinc,**  
**Inorganic Nitrogen, and Orthophosphorus for Coeur d'Alene Lake During**  
**Water Year 1999**

Dissolved Constituent	Annual Flux, Micrograms Per Square Centimeter		Percent Benthic Flux is of Riverine Flux
	Benthic <sup>a</sup>	Riverine <sup>b</sup>	
Cadmium	2.7	3.6	75
Lead	2.2	17	13
Zinc	314	540	58
Inorganic nitrogen	270	181	149
Orthophosphorus	14.6	12.7	115

<sup>a</sup> Median of *in-situ* benthic flux chamber values for main-channel and Mica Bay stations measured during August 1999, Tables 5.5-2 and 5.5-3

<sup>b</sup> Combined inflow loads of Coeur d'Alene and St. Joe Rivers used for flux calculation

**Table 5.6-1**  
**Mass Balances for Dissolved Cadmium, Lead, Zinc, Inorganic Nitrogen,**  
**and Orthophosphorus for Coeur d'Alene Lake, Water Year 1999**

Constituent	Input (kg/yr)		Transformation of Dissolved to Particulate (kg/yr)	(Transformation ÷ Input) × 100	Output <sup>c</sup> (kg/yr)
	Riverine <sup>a</sup>	Benthic <sup>b</sup>			
Cadmium	3,900	2,970	5,190	75.6	1,680
Lead	18,300	2,420	17,900	86.6	2,800
Zinc	580,000	345,000	445,000	48.1	480,000
Inorganic nitrogen	232,000	348,000	274,000	47.2	306,000
Orthophosphorus	16,300	18,800	18,300	52.1	16,800

<sup>a</sup> Input loads from Tables 5.1-1 and 5.1-2.

<sup>b</sup> Benthic fluxes from Table 5.5-4. Fluxes converted to loads via multiplication by surface area.

<sup>c</sup> Output loads from Table 5.1-1 and 5.1-2.

**Table 5.6-2**  
**Mass Balances for Particulate Cadmium, Lead, and Zinc**  
**for Coeur d'Alene Lake, Water Year 1999**

Constituent	Riverine Input <sup>a</sup> (kg/yr)	Transformation of Dissolved to Particulate (kg/yr)	Sedimentation of Particulates <sup>b</sup> (kg/yr)	(Sedimentation)÷(Riverine Input + Transformation) × 100	Output <sup>c</sup> (kg/yr)
Cadmium	1,100	5,190	5,770	91.7	520
Lead	250,000	17,900	248,000	92.6	20,000
Zinc	136,000	445,000	571,000	98.3	10,000

<sup>a</sup> Input loads from Table 5.1-1, calculated as whole-water recoverable minus dissolved.

<sup>b</sup> From Table 5.6-1.

<sup>c</sup> Output load from Table 5.1-1, calculated as whole-water recoverable minus dissolved.

**Table 5.6-3**  
**Parameters Used in Modeling of Dissolved Zinc in Coeur d'Alene Lake**  
**[Data from Woods and Beckwith (1997), Brennan et al. (2000), and Woods (2000a)]**

Parameter Name	Description	Parameter Type	Value
V	Lake volume	Constant	$2.8 \times 10^{12}$ L
SA	Surface area of sediment	Constant	$1.08 \times 10^{12}$ cm <sup>2</sup>
Qin	Annual discharge at inlet	Constant	$1.84 \times 10^{10}$ L/d
Qin_var	Monthly discharge at inlet	Variable	See Table 2
Qout	Annual discharge at outlet	Constant	Qout = Qin
Qout_var	Monthly discharge at outlet	Variable	Qin_var = Qout_var
C_Znin	Mean annual dissolved Zn in inflow	Constant	107 µg/L (see text for calculation)
C_Znin_var	Mean monthly dissolved Zn in inflow	Variable	See Table 2
C_Znout	Mean annual dissolved Zn in outflow	Constant	67 µg/L
C_Znout_var	Mean monthly dissolved Zn in outflow	Variable	See Table 2
qex	Molecular diffusion coefficient	Constant	$2.152 \times 10^{-4}$ /d
C_Znpw	Dissolved Zn in porewater	Constant	1609 µg/L (see text for calculation)
C_Zn1	Dissolved Zn in lake derived from riverine input	Calculated	
C_Zn2	Dissolved Zn in lake derived from benthic flux	Calculated	
C_Zntot	Total dissolved Zn in lake	Calculated	C_Zn1 + C_Zn2
k_scav	First order rate constant for conversion from dissolved to particulate Zn	Fit to C_Znout or C_Znout_var	C_Zntot = C_Znout or C_Zntot = C_Znout_var

**Table 5.6-4**

**Summary of Mean Monthly Discharge at Inlet and Mean Dissolved Zinc Concentrations in the Inflow and Outflow for WY99 [Data from Brennan et al. (2000) and Woods (2000a)]**

<b>Month</b>	<b>Inflow (Q<sub>in_var</sub>) L/d</b>	<b>Dissolved Zn in Inflow (C<sub>Znin_var</sub>) mg/L</b>	<b>Dissolved Zn in Outflow (C<sub>Znout_var</sub>) mg/L</b>
October	2.06 x 10 <sup>9</sup>	250	52
November	4.33 x 10 <sup>9</sup>	260	60
December	9.71 x 10 <sup>9</sup>	250	70
January	1.35 x 10 <sup>10</sup>	175	85
February	8.65 x 10 <sup>9</sup>	105	90
March	2.28 x 10 <sup>10</sup>	125	95
April	2.89 x 10 <sup>10</sup>	90	80
May	4.22 x 10 <sup>10</sup>	65	70
June	3.09 x 10 <sup>10</sup>	60	55
July	1.02 x 10 <sup>10</sup>	125	45
August	4.07 x 10 <sup>9</sup>	160	35
September	2.47 x 10 <sup>9</sup>	200	35

**Table 5.7-1**  
**Trophic-State Classification Based on Open-Boundary Values**  
**for Four Limnological Variables**

Limnological Variable <sup>a</sup>		Oligotrophic	Mesotrophic	Eutrophic
Total phosphorus (µg/L)	$\bar{x}$	8.0	26.7	84.4
	$\bar{x} \pm 1 SD$	4.8 - 13.3	14.5 - 49.0	48.0 - 189
	$\bar{x} \pm 2 SD$	2.9 - 22.1	7.9 - 90.8	16.8 - 424
Total nitrogen (µg/L)	$\bar{x}$	661	753	1875
	$\bar{x} \pm 1 SD$	371 - 1,180	485 - 1,170	861 - 4,081
	$\bar{x} \pm 2 SD$	208 - 2,103	313 - 1,816	395 - 8,913
Chlorophyll-a (µg/L)	$\bar{x}$	1.7	4.7	14.3
	$\bar{x} \pm 1 SD$	0.8 - 3.4	3.0 - 7.4	6.7 - 31.0
	$\bar{x} \pm 2 SD$	0.4 - 7.1	1.9 - 11.6	3.1 - 66.0
Secchi-disc transparency (m)	$\bar{x}$	9.9	4.2	2.4
	$\bar{x} \pm 1 SD$	5.9 - 16.5	2.4 - 7.4	1.5 - 4.0
	$\bar{x} \pm 2 SD$	3.6 - 27.5	1.4 - 13.0	0.9 - 6.7

<sup>a</sup>Annual geometric mean values and standard deviations

Notes:

m - meter

mg/L - microgram per

Source: Modified from Ryding and Rast (1989)

**Table 5.7-2**  
**Concentrations of Phosphorus and Nitrogen Measured in Coeur d'Alene Lake on June 2-3, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Nutrient Concentration (µg/L)					
				Total Phosphorus WWR	Ortho- phosphorus Dissolved	Total Nitrogen WWR	Total Ammonia Plus Organic Nitrogen WWR	Nitrite Plus Nitrate Dissolved	Ammonia Dissolved
472730116475900	CdA Lake at mouth of CdA River	19990602 1140	1.3	10	1	160	138	22	3
472235116450200	St. Joe River at mouth	19990602 1310	3	12	2	147	121	26	5
474030116480600	CdA Lake at outlet to Spokane River	19990603 1315	2	8	<1	155	144	11	5
472500116450000	CdA Lake, C5-Blue Point	19990602 1400	5	12	1	157	143	14	6
		19990602 1415	15	11	2	170	131	39	5
473054116500600	CdA Lake, C4-University Point	19990602 1450	5	9	1	129	111	18	3
		19990602 1500	35	11	2	299	221	78	9
473500116482000	CdA Lake, C3-Driftwood Point	19990603 0920	5	9	1	136	127	9	4
		19990603 0930	50	9	2	230	154	76	9
473900116453000	CdA Lake, C1-Tubb's Hill	19990603 1120	5	7	1	157	145	12	4
		19990603 1130	45	10	2	251	164	87	8
47373011641000	CdA Lake, C2-Wolf Lodge Bay	19990603 1220	5	8	<1	182	176	6	6
		19990603 1230	32	8	<1	237	189	48	23

**Table 5.7-2 (Continued)**  
**Concentrations of Phosphorus and Nitrogen Measured in Coeur d'Alene Lake on June 2-3, 1999**

Notes:  
CdA - Coeur d'Alene  
< - less than  
m - meters  
µg/L - micrograms per liter  
USGS - U.S. Geological Survey  
WWR - whole-water recoverable

**Table 5.7-3**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on July 29-30, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Nutrient Concentration (µg/L)						Chlorophyll-a Concentration (µg/L)
				Total Phosphorus WWR	Ortho- phosphorus Dissolved	Total Nitrogen WWR	Total Ammonia plus Organic Nitrogen WWR	Nitrite plus Nitrate Dissolved	Ammonia Dissolved	
472500116450000	CdA Lake, C5-Blue Point	19990729 1030	0-9	7	1	112	110	2	<1	1.3
		19990729 1045	14	9	1	143	141	2	1	ns
473054116500600	CdA Lake, C4-University Point	19990729 1330	0-12	8	1	128	126	2	<1	2.7
		19990729 1350	20	5	2	174	166	8	3	ns
		19990729 1415	38	4	2	175	89	86	<2	ns
473500116482000	CdA Lake, C3-Driftwood Point	19990730 0800	0-12	5	1	156	154	2	1	0.83
		19990730 0815	30	5	1	187	116	71	1	ns
		19990730 0830	58	6	2	202	110	92	1	ns

**Table 5.7-3 (Continued)**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on July 29-30, 1999**

Notes:

CdA - Coeur d'Alene

< - less than

m - meters

µg/L - micrograms per liter

ns - not sampled

USGS - U.S. Geological Survey

WWR - whole-water recoverable

**Table 5.7-4**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on August 30-31, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Nutrient Concentration (µg/L)						Chlorophyll-a concentration (µg/L)
				Total Phosphorus WWR	Ortho- phosphorus Dissolved	Total Nitrogen WWR	Total Ammonia plus Organic Nitrogen WWR	Nitrite plus Nitrate Dissolved	Ammonia Dissolved	
472500116450000	CdA Lake, C5-Blue Point	19990830 1200	0-13	10	1	na	138	<1	46	1.1
		19990830 1220	16	6	2	91	88	3	21	ns
473054116500600	CdA Lake, C4-University Point	19990830 1500	0-14	4	2	na	100	<1	7	0.7
		19990830 1520	20	3	1	101	86	15	24	ns
		19990930 1545	38	5	2	182	88	94	19	ns
473500116482000	CdA Lake, C3-Driftwood Point	19990831 0900	0-15	1	1	na	66	<1	26	0.79
		19990831 0930	25	2	2	131	109	22	87	ns
		19990831 1000	48	4	1	418	315	103	12	ns

**Table 5.7-4 (Continued)**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on August 30-31, 1999**

Notes:

CdA - Coeur d'Alene

< - less than

m - meters

µg/L - micrograms per liter

na - not applicable

ns - not sampled

WWR - whole-water recoverable

USGS - U.S. Geological Survey

**Table 5.7-5**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on September 21, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Nutrient Concentration (µg/L)						Chlorophyll-a concentration (µg/L)
				Total Phosphorus WWR	Ortho- phosphorus Dissolved	Total Nitrogen WWR	Total Ammonia plus Organic Nitrogen WWR	Nitrite plus Nitrate Dissolved	Ammonia Dissolved	
472500116450000	CdA Lake, C5-Blue Point	19990921 1330	0-11	9	2	na	101	<1	8	1.1
		19990921 1345	16	12	4	121	100	21	23	ns
473054116500600	CdA Lake, C4-University Point	19990921 1115	0-14	5	2	na	106	<1	20	0.55
		19990921 1130	20	4	2	115	84	31	8	ns
		19990921 1145	38	6	2	221	110	111	8	ns
473500116482000	CdA Lake, C3-Driftwood Point	19990921 0930	0-14	2	2	na	98	<1	10	0.64
		19990921 0945	30	5	1	161	92	69	8	ns
		19990921 1000	58	6	2	251	128	123	124	ns

Notes:

CdA - Coeur d'Alene

< - less than

m - meters

µg/L - micrograms per liter

na - not applicable

ns - not sampled

USGS - U.S. Geological Survey

WWR - whole-water recoverable

**Table 5.7-6**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on October 19, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Nutrient Concentration (µg/L)						Chlorophyll-a concentration (µg/L)
				Total Phosphorus WWR	Ortho- phosphorus Dissolved	Total Nitrogen WWR	Total Ammonia plus Organic Nitrogen WWR	Nitrite plus Nitrate Dissolved	Ammonia Dissolved	
472500116450000	CdA Lake, C5-Blue Point	19991019 1320	0-8	8	<1	172	150	22	<1	1
		19991019 1400	15	12	<1	415	400	15	<1	ns
473054116500600	CdA Lake, C4-University Point	19991019 1110	0-14	3	<1	111	94	17	<1	0.79
		19991019 1120	20	3	<1	167	146	21	<1	ns
		19991019 1130	38	5	<1	209	89	120	<1	ns
473500116482000	CdA Lake, C3-Driftwood Point	19991019 0915	0-14	3	<1	126	113	13	<1	ns
		19991019 0930	30	3	<1	200	120	80	<1	ns
		19991019 0945	55	5	<1	251	130	121	<1	ns

**Table 5.7-6 (Continued)**  
**Concentrations of Phosphorus, Nitrogen, and Chlorophyll-a Measured in Coeur d'Alene Lake on October 19, 1999**

Notes:

CdA - Coeur d'Alene

< - less than

m - meters

µg/L - micrograms per liter

ns - not sampled

USGS - U.S. Geological Survey

WWR - whole-water recoverable

**Table 5.7-7**  
**Median Concentrations of Cadmium, Lead, and Zinc Measured**  
**in Coeur d'Alene Lake During 1991-92, 1995-98, and 1999**

Constituent and sample depth category	1991-92 <sup>a</sup>	1995-98 <sup>b</sup>	1999 <sup>c</sup>
Cadmium, WWR (µg/L)	<1	<0.5	0.24
Near-surface	<1	<0.5	0.34
Near-bottom			
Cadmium, dissolved (µg/L)	—	<0.5	<b>0.22</b>
Near-surface	—	<0.5	<b>0.34</b>
Near-bottom			
Lead, WWR (µg/L)	2.4	<5	0.86
Near-surface	4.4	8	1.5
Near-bottom			
Lead, dissolved (µg/L)	—	<3	0.17
Near-surface	—	<b>4</b>	<b>2.3</b>
Near-bottom			
Zinc, WWR (µg/L)	81.8	74	45
Near-surface	115	117	80
Near-bottom			
Zinc, dissolved (µg/L)	—	<b>79</b>	42
Near-surface	—	<b>103</b>	<b>76</b>
Near-bottom			

<sup>a</sup> Year-round sampling, Woods and Beckwith (1997)

<sup>b</sup> May-November sampling, written communication, G. Harvey, IDEQ, May, 2000

<sup>c</sup> June-October sampling, Tables 5.7-8 to 5.7-12

Notes:

WWR - whole-water recoverable

mg/L - microgram per liter

— not sampled

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 µg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value of 30 mg/L CaCO<sub>3</sub>.

**Table 5.7-8**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on June 2-3, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Trace-element Concentration (µg/L)					
				Cadmium		Lead		Zinc	
				WWR	Dissolved	WWR	Dissolved	WWR	Dissolved
472730116475900	CdA Lake at mouth of CdA River	19990602 1140	1.3	0.71	<b>0.64</b>	30.6	<b>4.5</b>	96.2	<b>96.6</b>
472235116450200	St. Joe River at mouth	19990602 1310	3	0.07	0.07	0.18	0.02	2.84	2.71
474030116480600	CdA Lake at outlet to Spokane River	19990603 1315	2	0.36	<b>0.25</b>	10.5	<b>1.16</b>	62.3	<b>54.4</b>
472500116450000	CdA Lake, C5-Blue Point	19990602 1400	5	0.09	0.07	2.91	0.38	11.9	10
		19990602 1415	15	0.20	<b>0.17</b>	2.36	0.37	42.1	41.8
473054116500600	CdA Lake, C4-University Point	19990602 1450	5	0.30	<b>0.27</b>	11.8	<b>1.56</b>	44.2	42.5
		19990602 1500	35	0.44	<b>0.43</b>	6.07	<b>0.74</b>	85.6	<b>88.3</b>
473500116482000	CdA Lake, C3-Driftwood Point	19990603 0920	5	0.33	<b>0.28</b>	13.1	<b>1.3</b>	50.1	<b>49.5</b>
		19990603 0930	50	0.39	<b>0.38</b>	3.9	0.58	82.7	<b>86</b>
473900116453000	CdA Lake, C1-Tubb's Hill	19990603 1120	5	0.33	<b>0.29</b>	10.6	<b>1.26</b>	54.3	<b>53.3</b>
		19990603 1130	45	0.40	<b>0.38</b>	3.71	0.53	84	<b>90.1</b>
47373011641000	CdA Lake, C2-Wolf Lodge Bay	19990603 1220	5	0.29	<b>0.27</b>	2.8	0.54	58.4	<b>54.1</b>
		19990603 1230	32	0.34	<b>0.31</b>	2.3	0.37	76.6	<b>78.3</b>

Notes:

CdA - Coeur d'Alene

m - meters

WWR - whole-water recoverable

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 mg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value mg/L CaCO<sub>3</sub>.

µg/L - microgram per liter

USGS - U.S. Geological Survey

**Table 5.7-9**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on July 29-30, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Trace-element Concentration (µg/L)					
				Cadmium		Lead		Zinc	
				WWR	Dissolved	WWR	Dissolved	WWR	Dissolved
472500116450000	CdA Lake, C5-Blue Point	19990729 1030	0-9	0.19	<b>0.15</b>	1.91	0.21	36.8	27.8
		19990729 1045	14	0.26	<b>0.20</b>	2.45	0.16	53.6	<b>48.1</b>
473054116500600	CdA Lake, C4-University Point	19990729 1330	0-12	0.26	<b>0.20</b>	2.48	0.16	53.2	<b>48.5</b>
		19990729 1350	20	0.32	<b>0.26</b>	2.62	0.35	63.8	<b>63</b>
		19990729 1415	38	0.34	<b>0.38</b>	2.49	0.41	86.6	<b>86.7</b>
473500116482000	CdA Lake, C3-Driftwood Point	19990730 0800	0-12	0.25	<b>0.24</b>	1.45	0.25	45.7	41.8
		19990730 0815	30	0.43	<b>0.35</b>	2.2	0.40	80.6	<b>82.5</b>
		19990730 0830	58	0.47	<b>0.42</b>	2.38	0.49	88.1	<b>89.6</b>

**Table 5.7-9 (Continued)**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on July 29-30, 1999**

Notes:

CdA - Coeur d'Alene

m - meters

WWR - whole-water recoverable

µg/L - microgram per liter

USGS - U.S. Geological Survey

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 mg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value

**Table 5.7-10**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on August 30-31, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Trace-element Concentration (µg/L)					
				Cadmium		Lead		Zinc	
				WWR	Dissolved	WWR	Dissolved	WWR	Dissolved
472500116450000	CdA Lake, C5-Blue Point	19990830 1200	0-13	0.21	<b>0.19</b>	1.04	0.34	39.9	40
		19990830 1220	16	0.23	<b>0.20</b>	0.77	0.13	60.1	<b>62.9</b>
473054116500600	CdA Lake, C4-University Point	19990830 1500	0-14	0.25	<b>0.22</b>	0.85	0.16	53.3	<b>54.8</b>
		19990830 1520	20	0.31	<b>0.25</b>	1.64	0.21	66.9	<b>69.9</b>
		19990930 1545	38	0.40	<b>0.36</b>	1.81	0.46	83.7	<b>88.9</b>
473500116482000	CdA Lake, C3-Driftwood Point	19990831 0900	0-15	0.22	<b>0.22</b>	0.45	0.12	40.5	42.1
		19990831 0930	25	0.73	<b>0.28</b>	1.71	0.20	87.5	<b>73.0</b>
		19990831 1000	48	0.64	<b>0.33</b>	1.15	0.43	93.5	<b>70.3</b>

**Table 5.7-10 (Continued)**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on August 30-31, 1999**

Notes:

CdA - Coeur d'Alene

m - meters

WWR - whole-water recoverable

µg/L - microgram per liter

USGS - U.S. Geological Survey

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 mg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value of 30 mg/L CaCO<sub>3</sub>.

**Table 5.7-11**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on September 21, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Trace-element Concentration (µg/L)					
				Cadmium		Lead		Zinc	
				WWR	Dissolved	WWR	Dissolved	WWR	Dissolved
472500116450000	CdA Lake, C5-Blue Point	19990921 1330	0-11	0.21	<b>0.18</b>	0.74	0.20	41.9	39.7
		19990921 1345	16	0.30	<b>0.26</b>	1.32	0.19	64.2	<b>64.0</b>
473054116500600	CdA Lake, C4-University Point	19990921 1115	0-14	0.25	<b>0.26</b>	0.44	0.10	47.2	<b>47.4</b>
		19990921 1130	20	0.29	<b>0.27</b>	1.41	0.14	72.2	<b>73.9</b>
		19990921 1145	38	0.40	<b>0.38</b>	1.45	0.35	89.2	<b>93.6</b>
473500116482000	CdA Lake, C3-Driftwood Point	19990921 0930	0-14	0.28	<b>0.27</b>	0.35	0.09	47.0	<b>47.4</b>
		19990921 0945	30	0.34	<b>0.35</b>	0.95	0.20	78.6	<b>81.9</b>
		19990921 1000	58	0.48	<b>0.40</b>	1.47	0.3	93.2	<b>95.7</b>

**Table 5.7-11 (Continued)**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on September 21, 1999**

CdA - Coeur d'Alene

m - meters

WWR - whole-water recoverable

µg/L - microgram per liter

USGS - U.S. Geological Survey

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 mg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value of 30 mg/L CaCO<sub>3</sub>.

**Table 5.7-12**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on October 19, 1999**

USGS Station Number	Station Name	Sample Date and Time	Depth (m)	Trace-element Concentration (µg/L)					
				Cadmium		Lead		Zinc	
				WWR	Dissolved	WWR	Dissolved	WWR	Dissolved
472500116450000	CdA Lake, C5-Blue Point	19991019 1320	0-8	0.17	<b>0.12</b>	0.86	0.12	36.8	36.1
		19991019 1400	15	0.12	0.08	0.85	0.11	26.2	24.6
473054116500600	CdA Lake, C4-University Point	19991019 1110	0-14	0.26	<b>0.24</b>	0.63	0.18	51.5	<b>57.1</b>
		19991019 1120	20	0.31	<b>0.26</b>	0.80	0.16	54.4	<b>59</b>
		19991019 1130	38	0.39	<b>0.37</b>	1.06	0.26	90.6	<b>95.8</b>
473500116482000	CdA Lake, C3-Driftwood Point	19991019 0915	0-14	0.24	<b>0.21</b>	0.35	0.11	49.0	<b>53.2</b>
		19991019 0930	30	0.37	<b>0.34</b>	0.80	0.21	76.3	<b>84.2</b>
		19991019 0945	55	0.45	<b>0.38</b>	1	0.25	89.1	<b>95.6</b>

**Table 5.7-12 (Continued)**  
**Concentrations of Cadmium, Lead, and Zinc Measured in Coeur d'Alene Lake on October 19, 1999**

Notes:

CdA - Coeur d'Alene

m - meters

WWR - whole-water recoverable

µg/L - microgram per liter

USGS - U.S. Geological Survey

**Bold** indicates exceedance of ambient water quality criteria (AWQC) - AWQC are 0.11, 0.66, and 43 mg/L for dissolved cadmium, lead, and zinc, respectively. AWQC were calculated using a hardness value of 30 mg/L CaCO<sub>3</sub>.

**Table 5.9-1**  
**Loads of Cadmium, Lead, Zinc, Total Nitrogen and Total Phosphorus Exported**  
**From Coeur d'Alene Lake for Seven Water Years<sup>a</sup>**

Variable	Water year						
	1992	1993	1994	1995	1996	1997	1999
Annual mean discharge (cfs)	3,460	5,330	2,970	6,300	10,200	10,290	7,530
Annual load (kg/yr)							
Cadmium, WWR <sup>c</sup>	1,960	3,020	1,690	3,570	5,790	5,830	2,240
Cadmium, DISS <sup>d</sup>	2,090	3,220	1,800	3,810	6,200	6,240	1,680
Lead, WWR	17,600	37,600	16,100	37,000	81,600	100,000	23,300
Lead, DISS <sup>e</sup>	3,160	5,910	2,640	7,000	13,100	13,700	2,810
Zinc, WWR	321,000	455,000	263,000	578,000	890,000	862,000	490,000
Zinc, DISS	272,000	394,000	225,000	491,000	767,000	752,000	481,000
Total Phosphorus	31,300 <sup>b</sup>	–	–	–	–	–	85,000
Total Nitrogen	777,000 <sup>b</sup>	–	–	–	–	–	1,110,000

<sup>a</sup> Measured at USGS gaging station 12419000, Spokane River near Post Falls, Idaho

<sup>b</sup> Calendar year 1992

<sup>c</sup> For 1992-97, 38 of 50 concentrations were reported as <1 µg/L, assigned value at 0.5 µg/L in load model.

<sup>d</sup> For 1992-97, 16 of 21 concentrations were reported as <1 µg/L, assigned value at 0.5 µg/L in load model.

<sup>e</sup> For 1992-97, 13 of 21 concentrations were reported as <1 µg/L, assigned value at 0.5 µg/L in load model.

Notes:

cfs - cubic feet per second

DISS - dissolved

kg/yr - kilogram per year

WWR - whole-water recoverable

– - not measured

**Table 5.9-2**  
**Retention of Metal Loads in Coeur d'Alene Lake Over**  
**Low to High Discharge Conditions**

Parameter	1994 (low discharge)	1995 (average discharge)	1997 (high discharge)	1999 (120% of average discharge)	Median Retention (%)
Annual mean discharge, cfs	2,970	6,300	10,300	7,530	
<b>Zinc<sup>1</sup></b>					
Total Inflow, kg	460,000	880,000	1,400,000	1,570,000	
Total Outflow, kg	260,000	580,000	860,000	1,080,000	
% Retained	43	35	41	31	38
<b>Lead<sup>1</sup></b>					
Total Inflow, kg	88,000	470,000	1,300,000	590,000	
Total Outflow, kg	16,000	37,000	100,000	51,300	
% Retained	82	92	92	91	92
<b>Cadmium<sup>1</sup></b>					
Total Inflow, kg	3,800	7,200	11,000	10,400	
Total Outflow, kg	1,700	3,600	5,800	4,940	
% Retained	56	51	47	53	52

<sup>1</sup>Whole-water recoverable metals loads

## 6.0 REFERENCES

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### Section 5.0—Fate and Transport

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**ATTACHMENT 1**  
**Data Source References**

### Data Source References

Data Source References <sup>a</sup>	Data Source Name	Data Source Description	Reference
2	URS FSPA Nos. 1, 2, and 3	Fall 1997: Low Flow and Sediment Sampling	URS Greiner Inc. 1997. Field Sampling Plan Addendum 1 Sediment Coring in the Lower Coeur d'Alene River Basin, Including Lateral Lakes and River Floodplains
			URS Greiner Inc. 1997. Field Sampling Plan Addendum 2 Adit Drainage, Seep and Creek Surface Water Sampling
			URS Greiner Inc. 1997. Field Sampling Plan Addendum 3 Sediment Sampling Survey in the South Fork of the Coeur d'Alene River, Canyon Creek, and Nine-Mile Creek
3	URS FSPA No. 4	Spring 1998: High Flow Sampling	URS Greiner Inc. 1998. Field Sampling Plan Addendum 4 Adit Drainage, Seep and Creek Surface Water Sampling; Spring 1998 High Flow Event
4	MFG Historical Data Spring 1991	Spring 1991: High Flow Sampling	McCulley, Frick & Gillman, Inc. 1991. Upstream Surface Water Sampling Program Spring 1991 High Flow Event, South Fork Coeur d'Alene River Basin above Bunker Hill Superfund Site: Tables 1 and 2
5	MFG Historical Data Fall 1991	Fall 1991: Low Flow Sampling	McCulley, Frick & Gillman, Inc. 1992. Upstream Surface Water Sampling Program Fall 1991 Low Flow Event, South Fork Coeur d'Alene River Basin above Bunker Hill Superfund Site: Tables 1 and 2
6	EPA/Box Historical Data	Superfund Site Groundwater and Surface Water Data	CH2MHill. 1997. Location of Wells and Surface Water Sites, Bunker Hill Superfund Site. Fax Transmission of Map August 11, 1998
			Environmental Protection Agency. 1998. E-mail from Ben Cope July 15, 1998. Subject: 2 Datasets File Attached: BOXDATA.WK4
7	IDeq Historical Data	IDeq Water Quality Data	Idaho Department of Environmental Quality. 1998. Assortment of files from Glen Pettit for water years 1993 through 1996
			Idaho Department of Environmental Quality. 1998. E-mail from Glen Pettit October 6, 1998 Subject: DEQ Water Quality Data Files Attached: 1998 trend Samples.xls, 1997 trend Samples.xls

### Data Source References (Continued)

Data Source References <sup>a</sup>	Data Source Name	Data Source Description	Reference
8	EPA/NPDES Historical Data	Water Quality based on NPDES Program	Environmental Protection Agency. 1998. E-mail from Ben Cope August 11, 1998/September 2, 1998. Subject: Better PCS Data Files/Smelterville. Attached: PCS2.WK4, PCSREQ.698/TMT-PLAN.XLS
			Environmental Protection Agency. 1998. E-mail from Ben Cope August 5, 1998. Subject: State of Idaho Lat/Longs File Attached: PAT.DBF
			Environmental Protection Agency. 1998. E-mail from Ben Cope July 15, 1998. Subject: 2 Datasets File Attached: PCSDATA.WK4
10	URS FSPA No. 5	Common Use Areas Sampling	URS Greiner Inc. 1998. Field Sampling Plan Addendum 5 Common Use Areas: Upland Common Use Areas and Lower Basin Recreational Beaches; Sediment/Soil, Surface Water, and Drinking Water Supply Characterization
11	URS FSPA No. 8	Source Area Sampling	URS Greiner Inc. 1998. Field Sampling Plan Addendum 8 Tier 2 Source Area Characterization Field Sampling Plan
12	Historical Groundwater Data from MFG	1997 Annual Groundwater Data Report Woodland Park	McCulley, Frick & Gillman. 1998. 1997 Annual Groundwater Data Report Woodland Park
13	Historical Data from US Forest Service, Idaho Geological Survey and others	Historical Data on Inactive Mine Sites USFS, IGS and CCJM, 1994-1997, Prichard Creek, Pine Creek and Summit Mining District	Mackey K, Yarbrough, S.L. 1995. Draft Removal Preliminary Assessment Report Pine Creek Millsites, Coeur d'Alene District, Idaho, Contract No. 1422-N651-C4-3049
			Idaho Geological Survey. 1999. Site Inspection Report for the Abandoned and Inactive Mines in Idaho on U.S. Forest Service Lands (Region 1), Idaho Panhandle National Forest Vol. I, Prichard Creek and Eagle Creek Drainages
			Idaho Geological Survey. 1999. Site Inspection Report for the Abandoned and Inactive Mines in Idaho on U.S. Forest Service Lands (Region 1), Idaho Panhandle National Forest Vol. III, Coeur d'Alene River Drainage Surrounding the Coeur d'Alene Mining District (Excluding the Prichard Creek and Eagle Creek Drainages)
			Idaho Geological Survey. 1999. Site Inspection Report for the Abandoned and Inactive Mines in Idaho on U.S. Forest Service Lands (Region 1), Idaho Panhandle National Forest Vol. IV, Prichard Creek and Eagle Creek Drainages

### Data Source References (Continued)

Data Source References <sup>a</sup>	Data Source Name	Data Source Description	Reference
13	Historical Data from US Forest Service, Idaho Geological Survey and others (continued)		Idaho Geological Survey. 1999. Site Inspection Report for the Abandoned and Inactive Mines in Idaho on U.S. Forest Service Lands (Region 1), Idaho Panhandle National Forest Vol. V, Coeur d'Alene River Drainage Surrounding the Coeur d'Alene Mining District (Excluding the Prichard Creek and Eagle Creek Drainages) Part 2 Secondary Properties
			US Forest Service. 1995. Pilot Inventory of Inactive and Abandoned Mine Lands, East Fork Pine Creek Watershed, Shoshone County, Idaho
14	Historical Sediment Core Data: University of Idaho (Thesis papers)	Historical Lateral Lakes Sediment Data from F. Rabbi and M.L. Hoffman	Characterization of Heavy Metal Contamination in Two Lateral Lakes of the Lower Coeur d'Alene River Valley, A thesis by M.L. Hoffmann, May 1995
			Trace Element Geochemistry of Bottom Sediments and Waters from the Lateral Lakes of Coeur d'Alene River, A Dissertation by F. Rabbi, May 1994
15	URS FSPA No. 9	Source Area Characterization; Field XRF Data	CH2M Hill and URS Greiner. 1998. Field Sampling Plan Addendum 9 Delineation of Contaminant Source Areas in the Coeur d'Alene Basin using Survey and Hyperspectral Imaging Techniques
16	Historical Sediment Data	Electronic Data compiled by USGS	U.S. Geological Survey. 1992. Effect of Mining-Related Activities on the Sediment-Trace Element Geochemistry of Lake Coeue d'Alene, Idaho, USA--Part 1: Surface Sediments, USGS Open-File Report 92-109, Prepared by A.J. Horowitz, K.A. Elrick, and R.B. Cook
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17	USGS Spokane River Basin Sediment Samples	Surface Sediment Samples Collected by USGS in the Spokane River Basin	Environmental Protection Agency. 1999. Data Validation Memorandum and Attached Table from Laura Castrilli to Mary Jane Nearman dated June 9, 1999. Subject: Coeur d'Alene (Bunker Hill) Spokane River Basin Surface Sample Samples, USGS Metals Analysis, <63 um fraction, Data Validation, Samples SRH7-SRH30

### Data Source References (Continued)

Data Source References <sup>a</sup>	Data Source Name	Data Source Description	Reference
18	USGS Snomelt Surface Water Data	Surface Water Data from 1999 Snomelt Runoff Hydrograph	USGS. 1999. USGS WY99.xls Spreadsheet downloaded from USGS (Coeur d'Alene Office) ftp site
			USGS. 2000. Concentrations and Loads of Cadmium, Lead and Zinc Measured near the Peak of the 1999 Snomelt Runoff Hydrograph at 42 Stations, Coeur d'Alene River Basin Idaho
			USGS. 2000. Concentrations and Loads of Cadmium, Lead and Zinc Measured on the Ascending and Descending Limbs of the 1999 Snomelt Runoff Hydrograph at Nine Stations, Coeur d'Alene River Basin Idaho
22	MFG Report on Union Pacific Railroad Right-of-Way Soil Sampling	Surface and Subsurface Soil Lead Data	MFG. 1997. Union Pacific Railroad Wallace Branch, Rails to Trails Conversion, Right-of-Way Soil Sampling, Summary and Interpretation of Data. McCulley, Frick and Gilman, Inc. March 14, 1997
23	URS FSPA No. 11A	Source Area Groundwater and Surface Water Sampling	URS Greiner Inc. 1999. Field Sampling Plan Addendum 11A Tier 2 Source Area Characterization
24	URS FSPA No. 15	Common Use Area Sampling—Spokane River	URS Greiner Inc. 1999. Field Sampling Plan Addendum 15 Spokane River - Washington State Common Use Area Sediment Characterization
28	URS FSPA No. 18	Depositional and Common Use Area Sediment Sampling - Spokane River	URS Greiner Inc. 2001. Final Field Sampling Plan Addendum No. 18, Fall 2000 Field Screening of Sediment in Spokane River Depositional Areas, Summary of Results. Revision 1. January 2001.

<sup>a</sup>Reference Number is the sequential number used as cross reference to associate chemical results in data summary tables with specific data collection efforts.

**ATTACHMENT 2**  
**Data Summary Tables**

## **ABBREVIATIONS USED IN DATA SUMMARY TABLE**

### **LOCATION TYPES:**

AD adit  
BH borehole  
FP flood plain  
GS ground surface/near surface  
HA hand auger boring  
LK lake/pond/open reservoir  
OF outfall/discharge  
RV river/stream  
SP stockpile  
TL tailings pile

### **QUALIFIERS:**

U Analyte was not detected above the reported detection limit  
J Estimated concentration

### **DATA SOURCE REFERENCES:**

Data source references listed in Attachment 1 are included in the data summary tables in the "Ref" column.

# **Data Summary Table** **Coeur d'Alene Lake - segment CDALakeSeg01**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Surface Soil (mg/kg)</b>														
CUA01715	CS	10	08/06/1998	0	1 U	7	0.4 J	17.1	15600	40.3	348	0.1 U	0.41 U	102 J
CUA01716	CS	10	08/06/1998	0	1.8 J	3.5	0.26 J	14.4	29600	40.8	585	0.1 U	0.41 U	65.5 J
CUA01717	CS	10	08/06/1998	0	1 U	1.8 J	0.21 U	10	12300	17.5	235	0.11 U	0.42 U	42.7 J
CUA01718	CS	10	08/06/1998	0	1.1 U	2.6	0.21 U	12.9	15300	8.8	185	0.11 U	0.43 U	35.9 J
CUA01719	CS	10	08/06/1998	0	1 U	1.4 U	0.2 U	8.7	10600	10.1	146	0.1 U	0.4 U	26.6 J
CUA01720	CS	10	08/06/1998	0	1 U	4.3	0.43 J	12.4	15500	98.2	360	0.54	0.4 U	119 J
CUA01721	CS	10	08/06/1998	0	2.2 J	5.3	0.36 J	23.4	25200	53.1	596	0.1 U	0.4 U	87.5 J
<b>Sediment (mg/kg)</b>														
CUA0307	LK	10	08/07/1998	0	2.4 J	4	1.6	9.9	42700	31.7	578	0.1 U	0.4 U	327
LC10098	RV	16	---	0.07	2.1	15	11	33	42000	170	1100	0.14	1	1100
LC10099	RV	16	---	0.18	2.1	9	22	33	30000	70	400	0.09	1 U	1500
LC10100	RV	16	---	0.24	0.7	6.3	1.8	30	36000	35	700	0.06	1 U	354
LC10101	RV	16	---	0.61	0.7	4	0.5 U	31	34000	28	500	0.05	1 U	133
LC10113	RV	16	---	0.09	0.7	9	0.5 U	30	41000	21	1200	0.04	1 U	109
LC10114	RV	16	---	0.36	0.6	2.8	0.5 U	15	27000	17	500	0.04	1 U	88
LC10115	RV	16	---	0.09	0.8	6.5	0.5 U	31	41000	24	800	0.06	1 U	121
LC10117	RV	16	---	0.05	0.6	5	0.5 U	27	35000	16	700	0.04	1 U	84
LC10118	RV	16	---	0.19	0.7	4.1	0.5 U	26	31000	14	400	0.05	1 U	76
LC10119	RV	16	---	0.06	0.6	2.8	0.5 U	25	29000	14	300	0.03	1 U	77
LC10120	RV	16	---	0.24	0.8	3.9	0.5 U	31	29000	24	400	0.05	1 U	100
LC10121	RV	16	---	0.28	0.5	3	0.5 U	19	27000	14	400	0.02	1 U	65
LC10122	RV	16	---	0.27	0.5	2.9	0.5 U	18	26000	14	400	0.02	1 U	63
LC10123	RV	16	---	0.17	0.5	4.7	0.5 U	23	30000	17	400	0.05	1 U	76
LC10260	RV	16	---	0.62	18	530	37	73	62000	2410	13600	1.7	7	3400
LC10261	RV	16	---	0.52	16	160	33	65	60000	1750	6000	1.8	5	2800
LC10262	RV	16	---	0.5	15	250	32	62	54000	1800	6300	1.7	5	2900
LC10263	RV	16	---	0.64	13	230	39	64	52000	1670	8000	1.2	4	3300
LC10264	RV	16	---	0.66	17	90	36	63	52000	1460	5400	1.5	4	2800
LC10265	RV	16	---	0.57	7.8	60	31	50	50000	820	3300	0.91	2	2300
LC10266	RV	16	---	0.57	6.5	45	26	46	49000	590	2800	0.64	2	1900
LC10267	RV	16	---	0.79	9	210	30	53	52000	1150	8800	0.88	4	2600
LC10268	RV	16	---	0.53	9	60	36	53	53000	910	2100	0.91	3	2400
LC10269	RV	16	---	0.38	4	23	20	38	43000	330	1300	0.3	1	1500
LC10270	RV	16	---	0.43	1.1	5.8	2.3	19	30000	73	1000	0.04	1 U	360
LC10271	RV	16	---	0.2	0.8	8	0.5 U	30	40000	30	900	0.05	1 U	140

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg01**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10539	RV	16	06/15/1995	0		10.1 U	0.89		14700	18.9	826			62.5
LC10540	RV	16	06/15/1995	0		10.2 U	1.4		19300	22.1	200			56.9
LC10541	RV	16	06/15/1995	0		10.1 U	1.6		21600	12.8	277			45.3
LC10542	RV	16	06/15/1995	0		10.1 U	1		17800	25.3	224			68.1
LC10543	RV	16	06/15/1995	0		10.2 U	1.2		18100	22.8	231			53.6
LC10544	RV	16	06/15/1995	0		10.1 U	0.72		12800	11.3	268			49
LC10545	RV	16	06/15/1995	0		10.2 U	0.95		15900	20.4	177			62.1
LC10546	RV	16	06/15/1995	0		10.3 U	0.92		17300	32.4	119			40.6
LC10547	RV	16	06/15/1995	0		10.3 U	1.2		20000	20.6	82.6			43.9
LC10548	RV	16	06/15/1995	0		10.2 U	0.73		18000	22.1	242			45.4
LC10549	RV	16	06/15/1995	0		10.1 U	0.99		18000	21.6	255			52
LC10550	RV	16	06/15/1995	0		10.1 U	1.1		17700	20.9	365			48.3
LC10551	RV	16	06/16/1995	0		10.2 U	0.77		15100	16.2	206			45.2
LC10552	RV	16	06/16/1995	0		10.3 U	1		17400	19.7	237			51.7
LC10553	RV	16	06/16/1995	0		10.1 U	0.7		13300	20.3	147			53.3
LC10554	RV	16	06/16/1995	0		10.1 U	0.95		13300	19.4	197			53.8
LC10555	RV	16	06/16/1995	0		10.1 U	1.1		16500	15	276			66.4
LC10556	RV	16	06/16/1995	0		10.2 U	1.1		18000	16.9	206			60.6
LC10557	RV	16	06/16/1995	0		10.1 U	1.3		17500	21.3	216			65.2
LC10558	RV	16	06/16/1995	0		11.9	1.3		18400	13.8	129			44.9
LC10559	RV	16	06/16/1995	0		10.2 U	0.95		16900	20.6	212			56.1
LC10560	RV	16	06/16/1995	0		10.3 U	0.8		17000	20.7	236			56.7
LC10561	RV	16	06/16/1995	0		10.3 U	1.1		14400	14.5	108			44.4
LC10562	RV	16	06/16/1995	0		10.1 U	0.8		14100	13.1	105			43.5
LC10563	RV	16	06/26/1995	0		10.2 U	1.6		23700	14.9	162			61.5
LC10564	RV	16	06/26/1995	0		10.3 U	1.1		20600	13.1	207			54.5
LC10565	RV	16	06/26/1995	0		10.2 U	1		18400	10.5	193			49.9
LC10566	RV	16	06/26/1995	0		10.3 U	1.1		21800	16	194			63.5
LC10567	RV	16	06/26/1995	0		10.3 U	0.95		17400	11.4	242			46.5
LC10568	RV	16	06/26/1995	0		10.2 U	1.4		22500	15.2	176			60.5
LC10569	RV	16	06/26/1995	0		10.2 U	1.2		19600	11.3	176			51.5
LC10570	RV	16	06/27/1995	0		10.4 U	1.2		21300	15.8	247			55.1
LC10571	RV	16	06/27/1995	0		10.3 U	1.3		20500	20.1	204			67.2
LC10572	RV	16	06/27/1995	0		10.4 U	1.4		27100	19.3	362			64.1
LC10573	RV	16	06/27/1995	0		10.3 U	1.3		19800	22.2	182			68.1
LC10574	RV	16	06/27/1995	0		10.4 U	1.1		19300	20.7	211			89.1
LC10575	RV	16	06/28/1995	0		10.2 U	0.89		19400	10.7	158			50.6

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg01**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10576	RV	16	06/28/1995	0		10.3 U	1.6		20800	17.7	183			61.9
LC10577	RV	16	06/28/1995	0		10.3 U	1.4		19300	12.1	199			58.1
LC10578	RV	16	06/28/1995	0		10.8 U	1.3		22900	72	140			51.6
LC10579	RV	16	06/28/1995	0		10.2 U	1.1		21800	11.8	107			40.3
LC10580	RV	16	06/28/1995	0		10.4 U	1.1		20400	32.6	508			45.3
LC10581	RV	16	06/28/1995	0		10.3 U	0.36		20300	14.7	308			47.2
LC10582	RV	16	06/29/1995	0		10.2 U	0.34		21300	13.1	248			59.4
LC10583	RV	16	06/29/1995	0		10.1 U	0.37		21100	11.3	257			57
LC10584	RV	16	06/29/1995	0		10.4 U	1.4		18000	53.4	185			231
LC10585	RV	16	06/29/1995	0		10.1 U	0.3 U		20700	11.5	218			65.3
LC10586	RV	16	06/29/1995	0		10.2 U	0.53		22500	14	207			56.6
LC10587	RV	16	06/30/1995	0		10.3 U	0.33		24300	12.4	67			39.2
LC10588	RV	16	06/30/1995	0		10.4 U	0.31 U		28200	15.4	82.8			40.4
LC10589	RV	16	06/30/1995	0		10.2 U	0.31 U		27200	14.3	64			40.3
LC10590	RV	16	06/30/1995	0		12.2	0.35		19700	17.3	132			54.2
LC10591	RV	16	06/30/1995	0		10.4 U	0.47		23400	14.9	105			52.9
LC10592	RV	16	07/06/1995	0		10.1	0.99		14100	73.9	272			110
LC10593	RV	16	07/06/1995	0		10.1 U	0.6		14300	74	266			107
LC10594	RV	16	07/06/1995	0		10.2 U	0.61		25600	19.1	499			72.1
LC10595	RV	16	07/06/1995	0		10.2 U	0.66		27700	22.3	641			104
LC10596	RV	16	07/06/1995	0		10.2 U	0.71		25400	22.3	602			96.9
LC10597	RV	16	07/06/1995	0		10.2 U	0.51		18500	14.4	214			47.4
LC10598	RV	16	07/06/1995	0		10.1 U	0.3 U		18200	8.8	241			45.2
LC10599	RV	16	07/06/1995	0		10.1 U	0.37		17900	9.4	229			44.5
LC10600	RV	16	07/06/1995	0		10.1 U	0.41		17000	10.8	215			45.3
LC10601	RV	16	07/06/1995	0		10.3 U	0.31 U		11500	10.7	75.6			23.1
LC10602	RV	16	07/06/1995	0		10.2 U	0.43 U		13600	12.6	102			31.7
LC10603	RV	16	07/06/1995	0		10.2 U	0.31 U		19200	12	92.1			36.6
LC10604	RV	16	07/06/1995	0		10.2 U	0.97 U		16600	14	149			59.6
LC10605	RV	16	07/06/1995	0		10.2 U	0.45 U		21300	14.2	216			54.1
LC10606	RV	16	07/07/1995	0		10.2 U	0.45 U		21400	16.8	624			46.1
LC10607	RV	16	07/07/1995	0		10.1 U	0.5 U		19800	13.1	267			52
LC10608	RV	16	07/07/1995	0		10.2 U	0.46 U		19300	17.7	152			60
LC10609	RV	16	07/07/1995	0		10.3 U	0.69 U		21100	13.8	189			60.7
LC10610	RV	16	07/07/1995	0		10.6	0.31 U		25400	17.6	475			74.2
LC10846	RV	16	09/06/1995	0		10.1 U	0.6		24700	12.4	496			47.1
LC10847	RV	16	09/06/1995	0		10.2 U	0.51		19900	13.4	381			45.1

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg01**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10848	RV	16	09/06/1995	0		10.1 U	0.3 U		16800	10.6	276			36.2
LC10849	RV	16	09/06/1995	0		10.2 U	0.57		22800	14.7	412			51
LC10850	RV	16	09/06/1995	0		10.2 U	0.38		13400	8.8	244			61.9
LC10851	RV	16	09/06/1995	0		10.3 U	0.84		18700	23	292			53.7
LC10852	RV	16	09/06/1995	0		10.3 U	0.43		13300	25.2	176			57.6
LC10853	RV	16	09/07/1995	0		10.1 U	0.58		17800	10.6	282			40
LC10863	RV	16	09/07/1995	0		10.2 U	0.3 U		17300	10.7	290			40
LC10864	RV	16	09/07/1995	0		10.4 U	0.3 U		13800	11.4	79.1			20.1
LC10865	RV	16	09/07/1995	0		10.1 U	0.53		17400	11.9	248			44.3
LC10866	RV	16	09/07/1995	0		10.2 U	0.65		20700	13.6	250			48.6
LC10867	RV	16	09/07/1995	0		10.1 U	0.46		17100	11	273			34.7
LC10868	RV	16	09/11/1995	0		12.7	0.52		11900	14.6	47.2			20.5
LC10869	RV	16	09/11/1995	0		10.3 U	0.33		14000	13.8	36.4			17.8
LC10870	RV	16	09/11/1995	0		10.3 U	0.37		21000	14.4	45.7			19.7
LC10871	RV	16	09/11/1995	0		10.2 U	0.37		16800	13.1	175			42.3
LC10872	RV	16	09/11/1995	0		10.3 U	0.52		18100	16.6	37.5			22
LC10873	RV	16	09/11/1995	0		10.3 U	0.31 U		10700	10.6	19.7			10.2
LC10874	RV	16	09/11/1995	0		10.2 U	0.33		11500	11.2	144			18.5
LC10875	RV	16	09/11/1995	0		10.2 U	0.31 U		8830	8.3	58.6			18.7
LC11132	RV	16	11/21/1995	0		10.1 U	0.49		18100	9.8	548			21.7
LC11133	RV	16	11/21/1995	0		10.1 U	0.3 U		9260	7.9	111			19.9
LC11134	RV	16	11/21/1995	0		10.2 U	0.3 U		11800	10.6	174			31.1
LC11138	RV	16	11/28/1995	0		10.3 U	0.67		22400	15	361			98.7
LC11139	RV	16	11/28/1995	0		10.1 U	0.53		20100	15.3	313			76.1
LC11140	RV	16	11/28/1995	0		10.1 U	0.76		26200	16	399			87.3
LC11141	RV	16	11/28/1995	0		10.2 U	1.5		35700	18.2	607			114
LC11142	RV	16	11/28/1995	0		10.1 U	1.2		35300	15.3	663			105
LC11143	RV	16	11/29/1995	0		10.2 U	0.3 U		8200	10.5	122			24.8
LC11144	RV	16	11/29/1995	0		10.2 U	0.3 U		6910	9.9	38			18.8
LC11145	RV	16	11/29/1995	0		10.1 U	0.46		17900	11.9	268			44.2
LC11146	RV	16	11/29/1995	0		10.1 U	0.3 U		9910	11.2	114			25.3
LC11147	RV	16	11/29/1995	0		10.1 U	0.41		14300	9.5	227			35.4
LC11148	RV	16	11/29/1995	0		10.1 U	0.45		12500	8.3	136			33.4
LC11149	RV	16	11/29/1995	0		10.2 U	0.3 U		8390	10.5	45.3			25.5
LC11150	RV	16	11/29/1995	0		2 U	0.3 U		7290	4.8	118			24.5
LC11151	RV	16	11/29/1995	0		10.2 U	0.3 U		9250	19	310			48.3
LC11156	RV	16	12/20/1995	0		10.2 U	1.4		37700	17.6	1010			111

# Data Summary Table Coeur d'Alene Lake - segment CDALakeSeg01

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC11157	RV	16	12/20/1995	0		10.2 U	0.69		23100	17	514			79
LC11158	RV	16	12/20/1995	0		10.1 U	1.2		28500	15.1	507			90.9
LC11159	RV	16	12/20/1995	0		10.1 U	1.3		33600	15.5	604			103
LC11160	RV	16	12/20/1995	0		10.1 U	0.54		16200	18.1	161			60.5
LC11161	RV	16	12/20/1995	0		10.1 U	1.2		30900	16.2	542			93.1
LC11162	RV	16	12/20/1995	0		10.1 U	0.9		21200	18	364			74.3
LC11163	RV	16	12/21/1995	0		10.2 U	0.97		24900	14.5	360			81.9
LC11164	RV	16	12/21/1995	0		10.1 U	1.4		32000	17.8	521			101
LC11165	RV	16	12/21/1995	0		10.2 U	1.3		32200	19	507			102
LC11166	RV	16	12/21/1995	0		10.2 U	1.1		28900	20.5	710			100
LC11167	RV	16	12/21/1995	0		10.1 U	1.1		31200	17.1	473			97.8
LC11168	RV	16	12/21/1995	0		10.1 U	0.67		24900	14.6	360			86
LC11169	RV	16	12/21/1995	0		10.1 U	1.2		29200	15.6	427			91.3
LC11170	RV	16	12/21/1995	0		10.1 U	0.99		22500	14.1	302			74.9
LC11171	RV	16	12/21/1995	0		10.1 U	0.96		27600	16.3	412			92.9

## Surface Water - Total Metals (ug/l)

SJ4	RV	2	11/11/1997		0.095 U	0.31 UJ	0.069 U	2.4 J	243	4.8	18.1	0.1 U	0.22 U	12.5 U
SJ4	RV	3	05/06/1998		0.5 U	1 U	0.1 U	3 U	162 U	0.5 U	12.5	0.2 U	0.3 U	5 U
SJ50	RV	18	10/21/1998				1 UJ			1 UJ				10
SJ50	RV	18	11/19/1998				1 UJ			1 UJ				10
SJ50	RV	18	12/09/1998				1 UJ			1 UJ				10
SJ50	RV	18	01/26/1999				1 UJ			1 UJ				10
SJ50	RV	18	02/09/1999				1 UJ			1 UJ				10
SJ50	RV	18	03/10/1999				1 UJ			1 UJ				40
SJ50	RV	18	04/14/1999				1 UJ			1 UJ				40
SJ50	RV	18	07/14/1999				0.1 U			0.1 U				1 U
SJ50	RV	18	08/10/1999				0.1 U			0.1 U				1 U
SJ50	RV	18	09/09/1999				0.1 U			0.1 U				1 U
SJ55	RV	18	10/21/1998				1 UJ			1 UJ				10
SJ55	RV	18	11/19/1998				1 UJ			1 UJ				10
SJ55	RV	18	12/09/1998				1 UJ			1 UJ				10
SJ55	RV	18	01/26/1999				1 UJ			1 UJ				10
SJ55	RV	18	02/09/1999				1 UJ			1 UJ				10
SJ55	RV	18	03/10/1999				1 UJ			1 UJ				40
SJ55	RV	18	04/14/1999				1 UJ			1 UJ				40
SJ55	RV	18	06/07/1999											60

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg01**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Surface Water - Total Metals (ug/l)</b>														
SJ55	RV	18	07/14/1999				0.1 U			0.17				1.1
SJ55	RV	18	08/10/1999				0.1 U			0.1 U				1 U
SJ55	RV	18	09/09/1999				0.1 U			0.1 U				1 U
<b>Surface Water - Dissolved Metals (ug/l)</b>														
SJ4	RV	2	11/11/1997		0.5 U	0.28	0.04 U	1.7	88.8	1.01	7.7	0.2 U	0.03 U	4.2
SJ4	RV	3	05/06/1998		0.5 U	1 U	0.1 U	3 U	25 U	0.5 U	8.6	0.2 U	0.3 U	5 U
SJ50	RV	18	10/21/1998				1 UJ			1 UJ				20 UJ
SJ50	RV	18	11/19/1998				1 UJ			1 UJ				20 UJ
SJ50	RV	18	12/09/1998				1 UJ			1 UJ				20 UJ
SJ50	RV	18	01/26/1999				1 UJ			1 UJ				20 UJ
SJ50	RV	18	02/09/1999				1 UJ			1 UJ				20 UJ
SJ50	RV	18	03/10/1999				1 UJ			1 UJ				20 UJ
SJ50	RV	18	04/14/1999				1 UJ			1 UJ				20 UJ
SJ50	RV	18	05/10/1999				1 UJ			1 UJ				1 UJ
SJ50	RV	18	06/08/1999				1 UJ			1 UJ				1.2 UJ
SJ50	RV	18	07/14/1999				1 U			1 U				2
SJ50	RV	18	08/10/1999				1 U			1 U				1 U
SJ50	RV	18	09/09/1999				1 U			1 U				1 U
SJ55	RV	18	10/21/1998				1 UJ			1 UJ				20 UJ
SJ55	RV	18	11/19/1998				1 UJ			1 UJ				20 UJ
SJ55	RV	18	12/09/1998				1 UJ			1				20 UJ
SJ55	RV	18	01/26/1999				1 UJ			1 UJ				20 UJ
SJ55	RV	18	02/09/1999				1 UJ			1 UJ				20 UJ
SJ55	RV	18	03/10/1999				1 UJ			1 UJ				20 UJ
SJ55	RV	18	04/14/1999				1 UJ			1 UJ				20 UJ
SJ55	RV	18	05/10/1999				1 UJ			1				1
SJ55	RV	18	06/07/1999				1 UJ			1				1
SJ55	RV	18	07/14/1999				1 U			1 U				1 U
SJ55	RV	18	08/10/1999				1 U			1 U				1 U
SJ55	RV	18	09/09/1999				1 U			1 U				1 U

# Data Summary Table

## Coeur d'Alene Lake - segment CDALakeSeg02

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
Surface Soil (mg/kg)														
CL8169	TL	13	---			180	3.5	64	27000	63	400			56
CL8230	AD	13	---			130	3	37	26000	52	580			64
CL8270	TL	13	---			210	3.7	840	19000	* 8600	170			300
CL8272	TL	13	---			180	3.5	64	27000	63	400			56
CL8273	TL	13	---			160	4	130	38000	170	2600			390
CUA0011	GS	10	08/06/1998	0	1.2 U	12.5	2.4	33	23400	172	792	0.21	0.49 U	387
CUA0012	GS	10	08/06/1998	0	1.4 J		4.8	42.5	18100	255		0.18		
CUA0012	GS	10	08/06/1998	0		9.9					843		0.41 U	1110
CUA0013	GS	10	08/06/1998	0	2.1 J	7.9	1.5	34.6	17800	191	492	0.11 U	0.43 U	252
CUA0014	GS	10	08/06/1998	0	1.2 J	10.2	1.2	29	20400	183	798	0.11	0.41 U	207
CUA0015	GS	10	08/06/1998	0	1.1 U	9.2	3.8	26.2	18100	273	701	0.23	0.43 U	535
CUA0016	GS	10	08/06/1998	0	2.5 J	11.3	1.6	85.8	23300	359	1090	0.49	0.53 U	484
CUA0017	GS	10	08/06/1998	0	2.6 J	11.6	1.3 J	29.1	25700	107	642			263
CUA0017	GS	10	08/06/1998	0								0.11 U	0.46 U	
CUA01910	GS	10	08/11/1998	0	2.6 J	8.9			35900			0.11 U		
CUA01910	GS	10	08/11/1998	0			4	61.6		158	653 J		0.42 U	5720
CUA01911	GS	10	08/11/1998	0	1.1 U	9.2	1.2	16.1	28000	39.5	337 J	0.11 U	0.43 U	335
CUA01912	GS	10	08/11/1998	0	2.2 J	10.5	3	150	32900	130	477 J	0.11 U	0.45 U	1990
CUA01913	GS	10	08/11/1998	0	1.4 J	10	5.9 J	88	43100	64.9 J	392	0.06 J	1.2 J	1270
CUA01914	GS	10	08/11/1998	0	1.4 J	7.9	1.2 J	92.1	33800	163 J	455	0.05 UJ	1.1 J	2110
CUA0198	GS	10	08/11/1998	0	1.4 J	6.9	1.2	28.1	31300	48.4	353 J	0.1 U	0.41 U	659
CUA0199	GS	10	08/11/1998	0	1.7 J	11.5	1.7	44	37400	85.7	401 J	0.12	0.48 U	1210
CUA02310	GS	10	07/31/1998	0		4.3 J	1.6	19.7	26300	80.6	956 J	0.07 J	2.2	193 J
CUA02311	GS	10	07/31/1998	0		5.1 J	1.4	17.7	24200	72	882 J	0.07 J	2.2	178 J
CUA02312	GS	10	07/31/1998	0		4.4 J	3.3	19.4	20900	141	771 J	0.06 J	1.8 J	366 J
CUA02313	GS	10	07/31/1998	0	0.73 J	8.1 J	5.6	19.6	22600	194	900 J	0.08 J	2.2	769 J
CUA02314	GS	10	07/31/1998	0	1.4 J	23 J	8.3	41.1	24700	408	1740 J	0.05 U	3.2	1330 J
CUA0238	GS	10	07/31/1998	0	2.6 J	12.5 J	6.8	25.6	25700	353	820 J	0.05 U	2.5	807 J
CUA0239	GS	10	07/31/1998	0	1.5 J	5.8 J	2.6	18.8	29700	132	1130 J	0.07 J	2.9	266 J
CUA02410	GS	10	08/12/1998	0	1.1 J	5.5	0.62 J	29.5	19600	166 J	523	0.06 J	0.58 J	260
CUA02411	GS	10	08/12/1998	0		2.1	0.06 U	15.6	11600			0.1	0.42 J	55
CUA02411	GS	10	08/12/1998	0						54.2 J	567			
CUA02412	GS	10	08/12/1998	0		1.8 J	0.23 J	22.8	14900	23.7 J	399	0.05 J	0.39 J	82.8 J
CUA02413	GS	10	08/12/1998	0		2.8	0.06 U	18.4	15500	22.6 J	439	0.05 J	0.41 J	86 J
CUA02414	GS	10	08/12/1998	0		2 J	1.3	28.8	11800	42.6 J	142	0.05 J	0.3 J	65.2 J
CUA02429	GS	10	08/12/1998	0		18	0.06 U	41.7	25400	21.3 J	749	0.05 J	0.73 J	97.1 J
CUA02430	GS	10	08/12/1998	0		17	0.06 U	43.1	24200	28.8 J	714	0.07 J	0.78 J	109 J

# Data Summary Table

## Coeur d'Alene Lake - segment CDALakeSeg02

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Surface Soil (mg/kg)</b>														
CUA0248	CS	10	08/12/1998	0		3	1.4 J	29.3	18300	49.9 J	310	0.07 J	0.43 J	106
CUA0249	CS	10	08/12/1998	0		2.6	0.16 UJ	17.5	14900	14.5 J	392	0.06 J	0.32 J	47.5
CUA0251	CS	10	08/07/1998	0	0.7 UJ	5.9	2.4	22.6	24500	82.6 J	656	0.31	0.31 J	258
CUA0253	CS	10	08/07/1998	0	0.68 UJ			24.6	28600		613	0.32	0.56 J	
CUA0253	CS	10	08/07/1998	0		8.1	1.3			74.1 J				203
CUA0254	CS	10	08/07/1998	0	0.67 UJ	2.3	0.54 J	24.5	48900	25.5 J	1010	0.18 U	0.4 J	135
CUA0255	CS	10	08/07/1998	0	0.68 UJ	6.5	0.86 J	22.8	28800	62 J	695	0.3	0.38 J	161
CUA0256	CS	10	08/07/1998	0	0.67 UJ	4.7	1.3	18	27100	66.4 J	705	0.25 U	0.46 J	188
CUA0257	CS	10	08/07/1998	0	0.67 UJ	3.7	1.1	19.7	21100	90.7 J	402	0.28	0.33 J	176
CUA02610	CS	10	08/09/1998	0	1 U	7.2	1.8	13.8	15400	56.2	313	0.1 U	0.41 U	184
CUA02611	CS	10	08/09/1998	0	1.3 J	61.6	2.8	59.9	9920	135	392	0.1 U	0.4 U	346
CUA02612	CS	10	08/09/1998	0	2 J	7.6	3.1	14.5	13000	149	375	0.2	0.4 U	277
CUA02613	CS	10	08/09/1998	0	1.9 J	5.4	2.2	11.3	12100	91.6	362	0.11	0.41 U	192
CUA02614	CS	10	08/09/1998	0	1.3 J	4.8	1.5	11.1	13600	52.2	246	0.1 U	0.4 U	142
CUA02615	CS	10	08/09/1998	0	1.8 J	5.7	1.3	11.2	14600	60.4	258	0.09 U	0.41 U	142
CUA02616	CS	10	08/09/1998	0	1.4 J	7.6	2.4	14.9	14200	114	275	0.1 U	0.41 U	256
CUA02617	CS	10	08/09/1998	0	1.1 U			22				0.17		
CUA02617	CS	10	08/09/1998	0		8.4	3.8		14500	152	481		0.43 U	949
CUA02618	CS	10	08/09/1998	0	1.1 U	9.1	3.8	13.6	16100	110	452	0.11	0.44 U	844
CUA02715	CS	10	07/31/1998	0		3.2 J	0.24 U	18.5	17200	12.2	271 J	0.05 U	1.5 J	40.7 J
CUA02716	CS	10	07/31/1998	0		3.3 J		21.2	20200		294 J	0.05 U		
CUA02716	CS	10	07/31/1998	0			0.27 U			14.4			1.5 J	46.3 J
CUA02717	CS	10	07/31/1998	0		1.9 J	0.43 J	11.5	12000	18.7	212 J	0.05 U	0.9 J	49.5 J
CUA02718	CS	10	07/31/1998	0		2.9 J	0.89 J	13.6	13200	20.6	330 J	0.05 U	1.1 J	68.6 J
CUA02719	CS	10	07/31/1998	0		2.9 J	0.92 J	22.6	16400	19.9	391 J	0.05 U	1.4 J	64.4 J
CUA02720	CS	10	07/31/1998	0		2.1 J	0.87 J	18	13100	22.8	269 J	0.05 U	0.74 J	74.7 J
CUA02721	CS	10	07/31/1998	0	0.68 J	3.8 J	0.39 J	12.4	17700	18.3	383 J	0.05 U	1.4 J	62.4 J
<b>Sediment (mg/kg)</b>														
CUA00110	RV	10	08/06/1998	0	1.1 J	9.8	5.3	30.5	18400	265	833	0.12	0.41 U	855
CUA00111	RV	10	08/06/1998	0	1.1 U	10.1	5.4	16.6	22100	119	603	0.11 U	0.44 U	1140
CUA00112	RV	10	08/06/1998	0	1.1 U	5.1	1.1	12	13500	45.5	205	0.11 U	0.43 U	339
CUA00113	RV	10	08/06/1998	0	2 J	8.1	7.2	25.2	14700	350	599	0.18	0.43 U	750
CUA00114	RV	10	08/06/1998	0	1.8 J	16.5	9.8	16.8	19800	421	1070	0.18	0.44 U	1340
CUA00115	RV	10	08/06/1998	0	1.1 U	9.5	1.9	32.1	19900	142	540	0.12	2.7 U	720
CUA00116	RV	10	08/06/1998	0	1.1 U	10.7	12.5	115	21600	538	1220	0.32	0.45 U	1400
CUA00117	RV	10	08/06/1998	0	1.1 J	12.6	4.6	20.1	23300	64.9	468	0.11 U	0.43 U	1300

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA00118	RV	10	08/06/1998	0	1.4 J	13.4	10.3	23	29400	129	990	0.13 U	0.49 U	2060
CUA00119	RV	10	08/06/1998	0	1.1 U	6.1	1.8	11.7	13500	101	154	0.11 U	0.42 U	156
CUA00120	RV	10	08/06/1998	0	1.2 U	6.1	1.9	16	13700	126	89.8	0.12 U	0.49 U	170
CUA00121	RV	10	08/06/1998	0	1.1 U	8	2.3	13.9	16200	124	179	0.1 U	0.45 U	181
CUA0018	RV	10	08/06/1998	0	1.4 J	15.9	16.5	48.6	23600	804	1240	0.54	0.68 J	1850
CUA0019	RV	10	08/06/1998	0	2.7 J	20.6	35	96.3	24800	1290	2050	1.4	0.92 U	2220
CUA0021	LK	10	08/07/1998	0	0.66 UJ	11.4	4.1	23.3	18800	184 J	702	0.31	0.28 J	1270
CUA00215	LK	10	08/07/1998	0	0.66 UJ	5.9	1.5	16	16500	64.2 J	353	0.25 U	0.2 J	527
CUA00216	LK	10	09/13/1998	0	0.66 UJ	9.3	2.7	22.5 J	21200	90.7	397	0.05 UJ	0.24 J	747
CUA00217	LK	10	08/07/1998	0	0.66 UJ	7.6	4.2	22.1	17100	151 J	552	0.3	0.34 J	988
CUA00217	LK	10	09/13/1998	0	0.67 UJ	8.6	6.6	26.9 J	17000	170	545	0.05 J	0.26 J	1220
CUA00218	LK	10	08/07/1998	0	0.66 UJ	6.1	1.9	17.7	15300	98.9 J	359	0.3	0.3 J	1030
CUA00219	LK	10	08/07/1998	0	0.65 UJ	7.2	3.7	14	15500	146 J	473	0.26	0.2 J	1130
CUA0022	LK	10	08/07/1998	0	0.66 UJ	4.6	1.3	21.7	16100	90.7 J	320	0.18 U	0.14 U	891
CUA00220	LK	10	08/07/1998	0	1.5 J	7.8 J	4.2	20.8	22100	143	471	0.38 J	0.66 J	1200
CUA00221	LK	10	08/07/1998	0	1.9 J	10.1 J	7.2	27.6	20100	455	954	0.39 J	1.1 J	1540
CUA0023	LK	10	08/07/1998	0	0.66 UJ	6.1				111 J				1060
CUA0023	LK	10	08/07/1998	0			2.1	11.4	14900		361	0.28 J	0.39 J	
CUA0024	LK	10	08/07/1998	0	0.66 UJ	3.9	2.1	12.3	15000	109 J	248	0.31	0.14 U	1250
CUA0025	LK	10	08/07/1998	0	0.66 UJ	4.2	2.2	13.9	15300	104 J	187	0.31	0.14 U	1230
CUA0026	LK	10	08/07/1998	0	0.68 UJ	18.1	4	35.5	32300	97.8 J	996	0.29	0.29 J	1890
CUA0027	LK	10	08/07/1998	0	1.1 J	8.4	2.2	22.5	20600	215 J	311	0.31	0.23 J	1530
CUA0091	LK	10	08/10/1998	0	2.4 J	18.9 J	18.3	42.9	24600	730	1490	0.66 J	2 J	2210
CUA00910	LK	10	08/10/1998	0		9.5 J	3.4	19.9	23900	105	652	0.36 J	0.61 J	1000
CUA00911	LK	10	08/10/1998	0		12.9 J		0.06 U	21300	33.5	641	0.27 J	0.6 J	77.3
CUA00912	LK	10	08/10/1998	0		11.4 J	3.1	30.4	25800	99.8	580	0.31 J	0.63 J	847
CUA00913	LK	10	08/10/1998	0		14.3 J	2.4	19.2	19200	83.7	501	0.28 J	0.57 J	573
CUA00914	LK	10	08/10/1998	0		11.9 J	2.6	19.2	21300	78.9	511	0.26 J	0.53 J	848
CUA00915	LK	10	08/10/1998	0		14.7 J	1.5	18.4	18000	49.9	415	0.26 J	0.55 J	492
CUA00916	LK	10	08/10/1998	0		14.3 J	3.1	21.8	20900	93	531	0.32 J	0.73 J	
CUA00916	LK	10	08/10/1998	0										851 J
CUA00917	LK	10	08/10/1998	0		23.8 J	0.06 U	29.2	22400	32	557	0.26 J	0.48 J	115
CUA00918	LK	10	08/10/1998	0	1.3 J	29.1	1.8	64.8	23200	45.6 J	600	0.05 U	0.52 J	196 J
CUA00919	LK	10	08/10/1998	0		17.1	0.06 U	22.7 J	20000	22.9	447	0.05 UJ	0.51 J	130 J
CUA0092	LK	10	08/10/1998	0	1.5 J	12.8 J	18.5	49	24900	415	971	0.54 J	1.6 J	1860
CUA00920	LK	10	08/10/1998	0	2 J	9.6	11.7	39.5	18100	667	218	0.33	0.5 UJ	1500
CUA00921	LK	10	08/10/1998	0	1 U	6.4	1.3	7.3	14000	48.3	257	0.1 U	0.41 U	709

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA00922	LK	10	08/10/1998	0	1.6 J	11.4	2.1	14.4	16800	85.7	423	0.1 U	0.43 U	1220
CUA00923	LK	10	08/10/1998	0	1.4 J	9.6	1.9	14.8	18300	45.4	419	0.1 U	0.41 U	842
CUA00924	LK	10	08/10/1998	0	1.3 J	9.1	1.7	11.7	14500	49.6	297	0.1 U	0.4 U	735
CUA00925	LK	10	08/10/1998	0								0.1 U	0.4 U	
CUA00925	LK	10	08/10/1998	0	1.4 J	12.1	1.7	10.2	13200	34.3	259			799
CUA00926	LK	10	08/10/1998	0	1 U	8.1	1.4	8.9	13900	27.9	208	0.1 U	0.41 U	618
CUA0093	LK	10	08/10/1998	0		13.7 J	1.9	27.2	33100	49.2	1000	0.05 UJ	0.86 J	216
CUA0093	LK	10	08/10/1998	0	1.4 J									
CUA0094	LK	10	08/10/1998	0		11.6 J	6.2	26.2	35800	72	1200	0.05 UJ	0.93 J	651
CUA0095	LK	10	08/10/1998	0		10.1 J	3.9	23.5	25600	73.6	801	0.3 J	0.59 J	609
CUA0096	LK	10	08/10/1998	0		14.6 J	1.7	26.3 J	19800	36.3	546	0.32 J	0.55 J	203
CUA0097	LK	10	08/10/1998	0		14.2 J	0.56 J	32.2	19500	43.7	556	0.35 J	0.53 J	160
CUA0098	LK	10	08/10/1998	0		11.7 J	4.5	40.9	28100	176	970	0.33 J	1 J	1880
CUA0099	LK	10	08/10/1998	0	1.1 J	5.5 J	3.7	22.5	25500	129	780	0.26 J	0.72 J	925
CUA0101	LK	10	08/11/1998	0	1 U	4.8	3.5	17.5	16900	82.7	132	0.1 U	0.4 U	379
CUA01010	LK	10	08/11/1998	0	1 U	5.6	0.8 J	18	16100	37.1	134	0.1 U	0.4 UJ	252
CUA01011	LK	10	08/11/1998	0	1 U	4.1	0.84 J	10.8	13600	38.8	87.4	0.1 U	0.42 UJ	250
CUA01012	LK	10	08/11/1998	0	1 U	4.6	1 J	10.7	14900	31.8	131	0.1 U	0.4 UJ	284
CUA01013	LK	10	08/11/1998	0	1 U	5	3.2	13.5	16600	45.9	180	0.1 U	0.41 UJ	451
CUA01014	LK	10	08/11/1998	0	1 U	4.5	1.4	11.1	15900	34.9	161	0.1 U	0.41 UJ	310
CUA0102	LK	10	08/11/1998	0	0.97 U	2.5	0.58 J	9.1	11200	15.7	113	0.1 U	0.39 U	106
CUA0103	LK	10	08/11/1998	0								0.1 U		
CUA0103	LK	10	08/11/1998	0	0.97 U	4	0.9 J	9.6	17000	20.6	112		0.39 U	182
CUA0104	LK	10	08/11/1998	0	1 U	5.6	2.6	27.4	16100	34.8	98.8	0.21	0.4 U	289
CUA0105	LK	10	08/11/1998	0	1 U	6	2.1	13.8	19200	32.6	160	0.17	0.4 U	294
CUA0106	LK	10	08/11/1998	0	0.98 U	4.6	1.8	11.2	12300	28.8	101	0.1 U	0.39 U	276
CUA0107	LK	10	08/11/1998	0	0.98 U	6.3	2.2	14.2	17400	39.1	133	0.1 U	0.39 U	317
CUA0108	LK	10	08/11/1998	0	1 U	3.4	1.5	44.2	12800	224	103	0.1 U	0.4 U	346
CUA0109	LK	10	08/11/1998	0	1.2 J	4.6	0.86 J	8.6	11400	26.1	100	0.1 U	0.4 U	180
CUA0111	LK	10	08/11/1998	0	1.1 U	5.5	2.3	15.3	19900	72.1	158	0.11 U	0.43 U	493
CUA01110	LK	10	08/11/1998	0	1.4 J	5.6	2.1	22.7	14700		157	0.1 U	0.39 U	420
CUA01110	LK	10	08/11/1998	0						62.8				
CUA01111	LK	10	08/11/1998	0	1 U	4.4	3.4	18.8	11400	83	201	0.1 U	0.41 UJ	554
CUA01112	LK	10	08/11/1998	0	1 U	4.9	6.8	27.1	17400	239	586	0.1 U	0.41 UJ	684
CUA01113	LK	10	08/11/1998	0	0.99 U	7.5	3.1	15.9	16600	131	313	0.1 U	0.39 UJ	651
CUA01114	LK	10	08/11/1998	0	1 U	9.4	5.2	25.2	15300	240	701	0.1 U	0.41 UJ	831
CUA01115	LK	10	08/11/1998	0				14.2					0.39 UJ	

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA01115	LK	10	08/11/1998	0	0.97 U	8	4.4		14400	129	394	0.09 U		650
CUA01117	LK	10	08/11/1998	0	1 U	7.2	5.1	13.2	12800	140	409	0.1 U	0.41 U	679
CUA01118	LK	10	08/11/1998	0	1 U	6.2	7.4	16.9	11300	167	525	0.1 U	0.41 U	762
CUA0112	LK	10	08/11/1998	0	1 U	4.1	2.9	17.7	19900	72.6	157	0.11 U	0.41 UJ	420
CUA01120	LK	10	08/11/1998	0	1 U	3.9	1.4	11.3	16200	82.3	90.8	0.1 U	0.4 UJ	510
CUA01121	LK	10	08/11/1998	0	1 U	4.4	0.58 J	8.4	15000	56.1	99.5	0.1 U	0.4 UJ	316
CUA01122	LK	10	08/11/1998	0	1 U	3.5	0.96 J	10.2	10800	43.2	107	0.1 U	0.4 UJ	345
CUA01123	LK	10	08/11/1998	0	0.99 U		2.5					0.1 U	0.4 UJ	
CUA01123	LK	10	08/11/1998	0		3.4		10.2	10000	58.5	126			454
CUA01124	LK	10	08/11/1998	0	1 U	2.4	6.4	15.9	8790	85	158	0.1 U	0.4 UJ	620
CUA01125	LK	10	08/11/1998	0	1 U	4.7	3.1	14.8	8970	122	316	0.1 U	0.41 UJ	522
CUA01126	LK	10	08/11/1998	0	1 U	2.1	5.3	12.9	7670	63.3	156	0.1 U	0.4 UJ	519
CUA0113	LK	10	08/11/1998	0	1.1 U	8.9	3	18.1	23100	83	247	0.1 U	0.42 UJ	575
CUA0114	LK	10	08/11/1998	0	1 U	2.6	1.9	13.6	15200	48.2	140	0.1 U	0.41 U	394
CUA0115	LK	10	08/11/1998	0	1 U	4.6	3	14.3	17000	62	193	0.1 U	0.41 UJ	541
CUA0116	LK	10	08/11/1998	0	1.3 J	14	2.7	51.1	22300	75.3	238	0.1 U	0.42 U	636
CUA0117	LK	10	08/11/1998	0	1 U	4.7	1.8	17.1	23200	43.6	242	0.1 U	0.4 U	327
CUA0119	LK	10	08/11/1998	0	1 U	2.9	2.6	21	14200	55.5	224	0.1 U	0.4 U	527
CUA0121	LK	10	08/12/1998	0	0.64 UJ	6.9	2.4	37.2 J	16000	51.4	194	0.14	0.43 J	472
CUA01210	LK	10	08/12/1998	0	0.66 UJ	2.6 U	1.6	16.4 J	8460	27.9	112	0.16	0.3 U	352
CUA01211	LK	10	08/12/1998	0	0.66 UJ	4.2	1.8	17 J	11100	36.2	137	0.16	0.29 J	438
CUA01212	LK	10	08/12/1998	0	0.66 UJ	3.3 U	0.37 J	21.5 J	8040	33	102	0.19	0.18 U	272
CUA01213	LK	10	08/12/1998	0	0.66 UJ	2.6 U	1.4	10.5 J	8180	30.3	93.2	0.13	0.26 U	348
CUA01214	LK	10	08/12/1998	0	0.66 UJ		2.4	25.1 J				0.12		
CUA01214	LK	10	08/12/1998	0		5.3			9030	37.1	120		0.26 U	421
CUA0122	LK	10	08/12/1998	0	1.8 J	8.1	5.4	16.8 J	13600	75.3	465	0.16	0.55 J	946
CUA0123	LK	10	08/12/1998	0	0.93 J	4	5.2	56.1 J	9370	57	185	0.14	0.38 J	593
CUA0124	LK	10	08/12/1998	0	0.67 UJ	4.7	2	13.6 J	9570	40	165	0.12	0.24 J	396
CUA0125	LK	10	08/12/1998	0	0.66 UJ	9.1	3.6	22.8 J	15600	61.2	383	0.13	0.59 J	733
CUA0126	LK	10	08/12/1998	0	0.66 UJ	8.2	1.5	17 J	14500	57.3	284	0.27	0.52 J	482
CUA0127	LK	10	08/12/1998	0	0.81 J	5.1	2.2	13.5 J	10900	47.8	202	0.12	0.36 J	380
CUA0128	LK	10	08/12/1998	0	0.66 UJ	3.1	0.63 J	14.6 J	9840	26.1	115	0.12	0.26 J	361
CUA0129	LK	10	08/12/1998	0	0.66 UJ	2.9	1.7	15.4 J	9800	37	114	0.24	0.27 J	394
CUA0181	LK	10	08/06/1998	0	1.3 J	3.9	0.6 J	8.5	11500 J	121 J	195 J	0.14 UJ	1.3 J	184 J
CUA01815	LK	10	08/06/1998	0	5.9 J	18	3.6	58.7	38700	1740	1370	0.73	2.9	890
CUA01816	LK	10	08/06/1998	0	1 U	3	0.29 J	13.7	12900	70.7	233	0.11 U	0.41 U	75.1
CUA01817	LK	10	08/06/1998	0	4.6 J	8.4	2.4	41.3	15500	526	779	0.1 U	0.84 J	560

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA01818	LK	10	08/06/1998	0	1.5 J	4.9	1.4	19.6	17800	183	377	0.1 U	0.41 U	215
CUA01819	LK	10	08/06/1998	0	1 U	2.6	0.24 J	11.4	12500	33	197	0.1 U	0.4 U	45.1
CUA0182	LK	10	08/06/1998	0	2 J	9.4	1.6	26.3	16200 J	282 J	348 J	0.22 UJ	2.3	452 J
CUA01820	LK	10	08/06/1998	0	1 U	3.9		13.6	16700	53.7	259	0.1 U	0.42 U	70
CUA01820	LK	10	08/06/1998	0			0.39 J							
CUA01821	LK	10	08/06/1998	0	1 U		0.2 U					0.1 U	0.4 U	
CUA01821	LK	10	08/06/1998	0		3.8		12.8	16100	21.1	256			37.7
CUA01822	LK	10	08/06/1998	0	1 J	6.8	1.1	18.1	16200	211	341	0.1 U	0.4 U	256
CUA01823	LK	10	08/06/1998	0	4.5 J	11.6	1.5	28.6	23100	710	805	0.15	0.75 U	389
CUA01824	LK	10	08/06/1998	0	1.2 J	4.5	0.55 J	14.2	14600	139	373	0.11 U	0.53 U	90.9
CUA01825	LK	10	08/06/1998	0	8 J	35	4.5	60.2	27500	2990	1810	1.4	5.7 U	1380
CUA01826	LK	10	08/06/1998	0	55.6	158	14.8	171	54900	* 12100	4780	3.1	22.8	4310
CUA01827	LK	10	08/06/1998	0	0.98 U	3.3	0.34 J	13.9	11300	96.8	243	0.1 U	0.39 U	69.3
CUA01828	LK	10	08/06/1998	0	3.4 J	23.8	3.2	26.6	20400	1340	875	0.38	1.6 U	757
CUA01829	LK	10	08/06/1998	0	2.4 J	16.3	1.6	25.3	18800	1040	586	0.32	1.3 U	462
CUA0183	LK	10	08/06/1998	0	5.7 J	22.3	2.8	30.2	27400 J	429 J	759 J	0.21 UJ	4	577 J
CUA01830	LK	10	08/06/1998	0	3.5 J	22.2	2.7	27.3	20300	1070	797	0.22	1.8 U	772
CUA01831	LK	10	08/06/1998	0	1.8 J	10.2	1.2	22.4	17700	557	432	0.1 U	0.8 U	306
CUA01832	LK	10	08/06/1998	0	15.6	58	7.4	66.4	35500	* 4770	2820	1.4	9.3	1960
CUA01833	LK	10	08/06/1998	0	3.4 J	16.3	2	25.2	17100	1120	728	0.43	1.7 U	465
CUA0184	LK	10	08/06/1998	0		10.4		13.1						
CUA0184	LK	10	08/06/1998	0	2.1 J		1.9		15400 J	348 J	467 J	0.22 UJ	2.3	587 J
CUA0185	LK	10	08/06/1998	0	3.7 J	14.2	2.6	26.3	23900 J	594 J	592 J	0.54 J	4.8	522 J
CUA0186	LK	10	08/06/1998	0	3.3 J	20	4.8	27.9	18900 J	1030 J	1700 J	0.36 UJ	4.8	1010 J
CUA0187	LK	10	08/06/1998	0	4.5 J	19	2.2	22.9	17200 J	992 J	783 J	0.4 UJ	3.7	562 J
CUA0191	LK	10	08/11/1998	0	5.4 J	5.9	10.1	97.7	34200	218	303 J	0.1 U	0.42 U	3440
CUA01915	LK	10	08/11/1998	0	0.94 J	2.4	1.5 J	28.7	15900	55.7 J	195	0.09 J	0.49 J	590
CUA01916	LK	10	08/11/1998	0		2.1	0.57 J	15.3	15700	27.7 J	218	0.1 J	0.47 J	497
CUA01917	LK	10	08/11/1998	0		2.6	0.51 J	17.1	17700	21.4 J	177	0.06 J	0.55 J	533
CUA01918	LK	10	08/11/1998	0	2.9 J	5.9	1.7 J	24.9	20000	29.4 J	261	0.05 UJ	0.55 J	974
CUA01919	LK	10	08/11/1998	0	1.1 J	2.6	4.9 J	16.9	16700	45.8 J	180	0.08 J	0.66 J	843
CUA0192	LK	10	08/11/1998	0	1.8 J	3.6	2	54.3	19600	135	136 J	0.11 U	0.43 U	873
CUA01920	LK	10	08/11/1998	0	1.3 J	2.6	2.5 J	16.9	16700	30.4 J	185	0.07 J	0.43 J	760
CUA01921	LK	10	08/11/1998	0		3.8	0.43 J	22.3	23000	21.6 J	203	0.06 J	0.68 J	675
CUA0193	LK	10	08/11/1998	0	2.1 J	9.7	2.6	32.7	37700	38.8	250 J	0.13 U	0.51 U	825
CUA0194	LK	10	08/11/1998	0	3.9 J	8.2	3.2	109	36800		200 J			1180
CUA0194	LK	10	08/11/1998	0						108		0.12 U	0.48 U	

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA0195	LK	10	08/11/1998	0	3.9 J	6.2	5.6	45.7	34800	152	191 J	0.11 U	0.45 U	1510
CUA0196	LK	10	08/11/1998	0	7.4 J	8.4	7.7	36.1	37300	209	199 J	0.1 U	0.4 U	2160
CUA0197	LK	10	08/11/1998	0	9.9 J	10.3	7	92.1	48200	177	226 J	0.1 U	0.41 U	2390
CUA0233	LK	10	07/31/1998	0		4.2 J	2.5	27.9	27500	82.6	560 J	0.05 J	2.2	422 J
CUA0236	LK	10	07/31/1998	0	0.92 J	4.9 J	1.6	8.1	25100	110	461 J	0.05 U	2.1	367 J
CUA0241	LK	10	08/12/1998	0		0.71 J	0.78 J	35.9	19300	32.6 J	223	0.05 UJ	0.53 J	118
CUA02415	LK	10	08/12/1998	0		3.8	1.2	21.4	13200	23.4 J	197	0.05 J	0.34 J	304 J
CUA02416	LK	10	08/12/1998	0		19.1	0.24 J	31	21100	29.6 J	508	0.05 J	0.58 J	177 J
CUA02417	LK	10	08/12/1998	0		12.1	1.1	25	18600	32.3 J	420	0.05 J	0.54 J	290 J
CUA02418	LK	10	08/12/1998	0		27.1	0.06 U	32.5	22800	33.8 J	451	0.04 U	0.53 J	172 J
CUA02419	LK	10	08/12/1998	0		22.3	0.13 J	27.1	19200	27.6 J	404	0.05 J	0.46 J	167 J
CUA0242	LK	10	08/12/1998	0		11	0.4 J	39.4	21000	27.9 J	424	0.05 J	0.48 J	153
CUA02420	LK	10	08/12/1998	0		23.1	1.9	79.7	24100	44.5	487	0.06 J	0.6 J	202 J
CUA02421	LK	10	08/12/1998	0	1.3 J	17.5	0.78 J	29.4	18100	30 J	328	0.06 J	0.61 J	248 J
CUA0243	LK	10	08/12/1998	0	1.3 J	23.7	2 J		24400	38.2 J	521	0.05 UJ		
CUA0243	LK	10	08/12/1998	0				57.1					0.68 J	153
CUA0244	LK	10	08/12/1998	0		13	0.27 J	45.5	22000	24.4 J	351	0.05 UJ	0.48 J	113
CUA0245	LK	10	08/12/1998	0		3.3	0.37 J	29.7	20900	17.7 J	278	0.05 UJ	0.53 J	115
CUA0246	LK	10	08/12/1998	0		19.7	0.22 UJ	42.8	22000	38.1 J	731	0.05 UJ	0.52 J	148
CUA0247	LK	10	08/12/1998	0		10.5	3.1 J	34	20000	29.6 J	355	0.05 UJ	0.49 J	142
CUA0261	LK	10	08/09/1998	0	1 U	4.2	1.2	10.1	11500	74	96.3	0.1 U	0.4 U	243
CUA0262	LK	10	08/09/1998	0	0.97 U	5.7	2.1	11.9	13400	66	145	0.1 U	0.39 U	448
CUA0263	LK	10	08/09/1998	0	1 U	6.6	0.92 J	11.6	16600	33.2	211	0.09 U	0.4 U	200
CUA0264	LK	10	08/09/1998	0	1 U	4.1	1	9.2	10300	44.5	116	0.1 U	0.41 U	153
CUA0265	LK	10	08/09/1998	0	1 U	4.1	1.6	7.7	10600	49.8	110	0.1 U	0.4 U	282
CUA0266	LK	10	08/09/1998	0	1.4 J	5	2.6	6.8	13100	57.7	123	0.11	0.4 U	441
CUA0267	LK	10	08/09/1998	0	0.97 U		2.8	7.9	14400	59.8	136	0.1 U	0.39 U	449
CUA0267	LK	10	08/09/1998	0		5.5								
CUA0268	LK	10	08/09/1998	0	0.97 U	5	1.2	5.6	12200	43.9	110	0.1 U	0.39 U	261
CUA0269	LK	10	08/09/1998	0	0.99 U	4.6	2.8	7.1	12200	47.3	136	0.1 U	0.39 U	349
CUA0273	LK	10	07/31/1998	0		5.8 J	2.2	17.2	28200	22	641 J	0.05 U	2.2	306 J
CUA0274	LK	10	07/31/1998	0	0.84 J	4.2 J	1.7	28.5	29800	24	504 J	0.05 U	2.4	288 J
CUA0291	LK	10	08/31/1998	0	1.1 J	5.5	4.1 J	11.9	21200	226	296	0.14 U	0.76 J	461
CUA0292	LK	10	08/31/1998	0	0.89 J	5.6	4.9 J	11.4	19300	180	330	0.1 U	0.57 J	624
CUA0293	LK	10	08/31/1998	0	0.67 UJ	5.5	1 J	10	24900	59.1	268	0.05 U	0.45 J	168
CUA0294	LK	10	08/31/1998	0	0.67 UJ	4.8	2.4 J	8.6	18400	89.7	303	0.05 U	0.46 J	365
CUA0295	LK	10	08/31/1998	0	0.67 UJ	5.1	1.5 J	7.1	16500	52.5	176	0.05 U	0.36 J	261

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA0296	LK	10	08/31/1998	0	0.67 UJ	5.2	0.87 J	8.4	19300	50	143	0.05 U	0.4 J	177
CUA0297	LK	10	08/31/1998	0	0.67 UJ	4.7	4.2 J	20.6	23000	223	290	0.07 U	0.68 J	503
LC10097	RV	16	---	0.87	42	100	* 141	121	44000	2960	1800	2.7	8	6500
LC10116	RV	16	---	0.09	19	40	* 87	57	29000	1480	4700	0.53	2	6200
LC10124	RV	16	---	0.28	39	23	* 103	123	40000	* 4790	1300	2.8	10	6100
LC10125	RV	16	---	1.13	22	57	* 157	86	32000	1840	1100	2.2	5	6100
LC10126	RV	16	---	1.4	44	85	* 113	97	59000	2310	8300	3.2	7	6200
LC10127	RV	16	---	0.35	8	20	* 83	53	24000	940	500	0.62	2	4400
LC10128	RV	16	---	1.41	45	150	* 120	112	51000	2540	3300	3.4	8	6400
LC10129	RV	16	---	1.35	32	104	* 128	100	49000	2290	2400	2.6	7	6800
LC10130	RV	16	---	1.22	39	126	* 126	112	51000	2670	2800	2.9	8	6300
LC10131	RV	16	---	1.39	16	182	* 77	64	44000	940	16000	1.2	3	4300
LC10132	RV	16	---	1.58	27	140	* 114	79	48000	1370	17800	2.5	5	5800
LC10133	RV	16	---	1.47	26	75	* 114	90	53000	2320	5800	2.5	6	5400
LC10134	RV	16	---	0.32	54	182	* 132	122	59000	3080	4900	3.8	10	7000
LC10135	RV	16	---	0.52	16	24	* 74	69	37000	1870	1200	1.4	4	4100
LC10136	RV	16	---	1.02	50	90	* 131	108	50000	2860	4700	3.9	8	6200
LC10137	RV	16	---	0.87	65	196	* 127	131	59000	3060	7500	4.8	11	7500
LC10138	RV	16	---	0.06	11	17	* 148	63	21000	1390	400	0.74	3	9100
LC10139	RV	16	---	1.68	37	122	* 78	100	58000	3200	15400	2.5	8	4200
LC10140	RV	16	---	1.28	27	94	* 126	95	50000	2370	7300	3	7	5700
LC10141	RV	16	---	0.16	2	16	13	26	20000	140	700	0.12	1 U	570
LC10149	RV	16	---	1.15	22	69	* 133	75	33000	1370	800	1.5	4	7200
LC10150	RV	16	---	1.25	41	120	* 112	108	52000	2650	4200	2.6	7	5800
LC10151	RV	16	---	1.17	24	110	* 87	77	54000	1830	10800	1.9	5	4900
LC10152	RV	16	---	1.26	67	180	* 96	150	57000	3810	4400	3.9	12	6400
LC10163	RV	16	---	0.53	1.4	8.4	3.3	21	34000	130	900	0.08	1 U	530
LC10164	RV	16	---	1.05	12	100	34	47	45000	970	4500	1.3	2	2400
LC10165	RV	16	---	0.52	59	94	* 133	131	49000	3640	3000	4.9	11	7100
LC10166	RV	16	---	1.76	25	58	* 102	83	52000	2160	6900	2.5	5	5300
LC10167	RV	16	---	0.43	34	96	* 130	99	56000	2740	10200	3.5	7	6600
LC10168	RV	16	---	1.45	31	156	* 89	80	53000	2400	9800	3.2	6	6100
LC10169	RV	16	---	1.46	26	156	* 103	79	51000	2060	19600	2.5	5	5300
LC10170	RV	16	---	1.28	13	50	* 79	68	46000	1590	9100	1.4	3	3900
LC10171	RV	16	---	0.7	76	92	46	215	73000	* 6830	8400	3.5	21	4600
LC10172	RV	16	---	0.92	22	112	* 69	67	50000	1720	17200	2	4	3700
LC10173	RV	16	---	0.48	45	116	* 129	103	60000	3000	9900	4.8	8	7100

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10174	RV	16	---	0.27	27	96	* 80	71	53000	1800	6200	2.5	5	5500
LC10175	RV	16	---	1.33	4	24	27	33	38000	370	1100	0.36	1	2200
LC10176	RV	16	---	1.41	42	144	* 112	110	54000	2700	4900	3.8	9	6000
LC10177	RV	16	---	1.3	49	142	* 116	116	55000	2760	5200	4.5	9	6100
LC10178	RV	16	---	1.42	15	178	* 81	63	41000	1460	14100	1.3	3	3900
LC10179	RV	16	---	1.58	35	115	* 110	99	52000	2480	5000	3.6	7	5500
LC10180	RV	16	---	1.82	17	60	* 81	72	46000	1820	6800	1.7	4	4200
LC10181	RV	16	---	1.15	25	70	* 95	87	51000	2400	4900	2	6	4800
LC10182	RV	16	---	1.64	15	240	58	65	47000	1640	9200	1.3	4	3400
LC10183	RV	16	---	1.74	45	200	* 90	107	54000	2570	9200	4.6	9	4900
LC10184	RV	16	---	1.27	40	82	* 92	106	54000	2550	5200	2.3	9	4900
LC10185	RV	16	---	1.09	18	190	* 93	68	45000	1610	8600	2.1	4	4500
LC10186	RV	16	---	1.79	12	210	61	60	43000	1290	7300	1.1	3	3200
LC10187	RV	16	---	1.59	35	120	* 108	99	50000	2400	3800	2.7	7	5100
LC10188	RV	16	---	0.98	23	230	* 88	74	47000	1930	12500	2.4	5	4400
LC10189	RV	16	---	0.46	13	190	62	59	43000	1320	7400	1.8	3	3100
LC10190	RV	16	---	1.29	46	160	* 92	97	57000	2610	8200	3.3	8	4800
LC10191	RV	16	---	1.09	14	240	66	64	47000	1720	12800	1.1	4	3500
LC10192	RV	16	---	1.24	12	60	59	60	44000	1540	21000	1.1	3	2600
LC10193	RV	16	---	0.49	20	110	* 72	72	50000	2020	7100	1.6	5	4000
LC10194	RV	16	---	1.3	7	150	30	36	40000	710	6800	0.68	1	2300
LC10195	RV	16	---	1.37	27	350	* 85	79	47000	2100	7600	2.6	5	4800
LC10196	RV	16	---	0.54	27	320	* 101	77	47000	2020	11600	2.7	5	5200
LC10197	RV	16	---	0.75	14	80	49	58	44000	1490	24600	1.1	3	2900
LC10198	RV	16	---	1.23	11	120	46	55	43000	1210	9400	1.2	3	2400
LC10199	RV	16	---	1.26	19	230	* 69	69	46000	1710	8300	1.8	4	3700
LC10200	RV	16	---	1.3	13	130	59	62	44000	1540	6900	1	3	3200
LC10201	RV	16	---	0.68	13	190	62	61	43000	1380	6400	1.2	3	3500
LC10202	RV	16	---	1.3	13	80	49	59	47000	1620	20000	1.01	3	2900
LC10203	RV	16	---	1.31	14	170	52	62	44000	1400	7100	0.96	3	2800
LC10204	RV	16	---	0.97	22	270	65	71	46000	1720	8400	2.7	5	3200
LC10205	RV	16	---	0.64	15	250	64	62	43000	1420	8000	1.2	3	3500
LC10206	RV	16	---	1.4	13	240	47	56	45000	1350	10700	1.5	3	2900
LC10207	RV	16	---	1.38	25	310	* 82	78	47000	2100	6100	2.4	5	4500
LC10208	RV	16	---	1.08	14	190	59	62	44000	1400	7100	1.2	3	3100
LC10209	RV	16	---	1.14	16	430	45	65	54000	2060	19000	1.2	5	3200
LC10210	RV	16	---	1.31	15	220	54	65	47000	1620	7400	1.3	4	3200

**Data Summary Table**  
**Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10211	RV	16	---	1.41	30	270	65	83	50000	2150	7000	3.1	6	3800
LC10212	RV	16	---	1.39	20	300	* 75	70	45000	1690	8200	2.3	4	4000
LC10213	RV	16	---	0.51	19	290	63	71	47000	1750	8900	1.8	5	3600
LC10214	RV	16	---	1.34	16	210	51	65	45000	1490	8700	1.3	4	2700
LC10215	RV	16	---	1.3	43	400	* 87	104	57000	2620	6500	4.8	9	4800
LC10216	RV	16	---	0.68	17	230	56	65	48000	1570	5300	1.5	4	3300
LC10217	RV	16	---	0.36	17	275	50	69	49000	1980	14000	1.3	5	3200
LC10218	RV	16	---	1.2	21	110	* 96	76	51000	2130	9200	1.9	5	5900
LC10224	RV	16	---	0.56	15	28	* 157	81	31000	2170	600	1.4	4	7200
LC10225	RV	16	---	1.12	29	230	67	77	53000	1980	8100	2.9	5	3600
LC10226	RV	16	---	0.37	15	110	44	68	50000	1730	7000	1.4	4	2800
LC10227	RV	16	---	0.57	2.2	2.4	1.3	18	31000	45	700	0.04	1 U	230
LC10228	RV	16	---	0.64	4	40	14	32	42000	390	3300	0.33	1	1300
LC10229	RV	16	---	0.87	8	160	33	46	49000	880	11200	0.86	2	2400
LC10230	RV	16	---	1.04	7	160	28	43	47000	870	12300	0.53	2	2300
LC10231	RV	16	---	0.97	22	170	* 70	72	47000	1400	4200	2.6	4	3600
LC10232	RV	16	---	1.07	15	100	43	65	44000	1220	3800	1.7	3	2300
LC10233	RV	16	---	0.79	10	40	38	56	45000	960	3000	0.86	3	2000
LC10234	RV	16	---	1.28	30	65	* 131	109	44000	2770	1800	2.8	7	6100
LC10235	RV	16	---	0.91	12	170	32	44	46000	1140	5600	1.4	3	2400
LC10236	RV	16	---	1.15	18	520	46	68	53000	2090	16600	1.3	5	3200
LC10237	RV	16	---	1.17	14	580	43	62	53000	1700	17400	1	4	2900
LC10238	RV	16	---	1.23	28	270	* 70	85	55000	2090	9000	3.8	6	3700
LC10239	RV	16	---	1.22	19	200	61	77	53000	2010	6300	1.7	6	3500
LC10240	RV	16	---	1.09	18	310	52	71	54000	2050	11700	1.3	6	3300
LC10241	RV	16	---	1.11	19	410	44	71	54000	2190	13200	1.3	6	3100
LC10242	RV	16	---	1.13	22	220	48	83	57000	2380	8500	1.6	8	3100
LC10243	RV	16	---	0.78	20	540	38	72	59000	2180	20400	1.4	7	2900
LC10244	RV	16	---	0.68	11	130	21	60	39000	1050	4900	1.2	4	1600
LC10245	RV	16	---	0.72	14	260	27	57	47000	1540	8700	1	5	2100
LC10246	RV	16	---	0.7	20	470	33	78	54000	2320	8900	2	7	2600
LC10247	RV	16	---	0.56	27	500	34	91	69000	3200	11500	2.2	10	3200
LC10248	RV	16	---	0.62	27	500	28	90	69000	3290	7400	2.4	10	3000
LC10249	RV	16	---	0.6	25	660	33	85	65000	2930	10000	2.1	8	2900
LC10250	RV	16	---	0.57	32	460	31	98	76000	3620	8000	2.6	11	3100
LC10251	RV	16	---	0.64	17	150	24	65	53000	2220	6100	1.5	7	2600
LC10252	RV	16	---	0.55	32	270	31	95	74000	3860	8300	2.5	11	3400

# **Data Summary Table** **Coeur d'Alene Lake - segment CDALakeSeg02**

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
LC10253	RV	16	---	0.09	34	200	31	112	85000	* 4790	7000	3	14	3800
LC10257	RV	16	---	0.33	37	180	34	110	91000	4400	7700	3.2	13	4200
LC10259	RV	16	---	0.65	29	290	32	97	74000	3850	12500	2.5	13	3600

## **Surface Water - Total Metals (ug/l)**

CL8135	AD	13	---		380	12	35 U	12 U	15 U	4	5 U		690
CL8136	AD	13	---		260	4	35 U	12 U	2.2	2 U	5 U		11
CL8230	AD	13	---		12	7	35 U	71	3	9	5 U		3 U
CL8231	AD	13	---		29 U	3 U	35 U	12 U	15 U	2 U	5 U		3 U

## **Surface Water - Dissolved Metals (ug/l)**

CL8135	AD	13	---		7.1	15	3.7 U		1.2 U				670
CL8136	AD	13	---		2.3 U	8.4 U	3.7 U		1.2 U				14
CL8230	AD	13	---		3.3	8 U	3.7 U		4				6.6
CL8231	AD	13	---		2.3 U	8 U	3.7 U		2 U				6

# Data Summary Table Coeur d'Alene Lake - segment CDALakeSeg03

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Surface Soil (mg/kg)</b>														
CL8154	SP	13	---			83	3.3	48	39000	82	550			100
CL8185	TL	13	---			1000	5.3	170	61000	2300	1700			280
CL8186	TL	13	---			190	4.6	53	44000	140	390			200
CL8187	TL	13	---			* 2500	7.1	130	77000	1100	280			420
<b>Sediment (mg/kg)</b>														
CUA0151	LK	10	08/05/1998	0	1.2 J	7.9 J	24.6	41.4 J	20000	110 J	706	0.2 UJ	0.59 J	1290
CUA01515	LK	10	08/05/1998	0		7.9 J	1.1	20 J	21200	27 J	285	0.1 UJ	0.43 J	155
CUA01516	LK	10	08/05/1998	0		5.6 J	0.86 J	29.8 J	17300	32.4 J	138	0.09 UJ	0.77 J	175
CUA01517	LK	10	08/05/1998	0		6 J	2.6	17.2 J	18400	50.3 J	136	0.17 UJ	0.55 J	402
CUA01518	LK	10	08/05/1998	0		6.7 J	1.4	16.6 J	18100	54.3 J	110	0.12 UJ	0.92 J	359
CUA01519	LK	10	08/05/1998	0		6.9 J	1.1	21.9 J	25000	39.3 J	164	0.41 J	0.7 J	219
CUA0152	LK	10	08/05/1998	0		6 J	9.8	264 J	20800	118	352 J	0.13 UJ	0.44 J	1000
CUA01520	LK	10	08/05/1998	0		7.1 J	0.83 J	34.4 J	29600	33.2 J	236	0.09 UJ	0.61 J	216
CUA01521	LK	10	08/05/1998	0		11 J	2.9	84.5 J	31100	51.8 J	279	0.1 UJ	0.65 J	766
CUA0153	LK	10	08/05/1998	0		4.8 J	3.4	20.3 J	21600	66.4 J	215	0.14 UJ	0.42 J	477
CUA0154	LK	10	08/05/1998	0				29.7 J						
CUA0154	LK	10	08/05/1998	0		8.3 J	8		29600	78.3 J	278	0.11 UJ	0.58 J	929
CUA0155	LK	10	08/05/1998	0		9.3 J	7.4	66.5 J	33800	76.2 J	331	0.1 UJ	1.1 J	930
CUA0156	LK	10	08/05/1998	0		8.3 J	16.5	33.3 J	27300	95 J	597	0.18 UJ	0.8 J	1170
CUA0157	LK	10	08/05/1998	0		8 J	4.1	112 J	31400	60.8 J	363	0.11 UJ	0.71 J	878
CUA0161	LK	10	08/05/1998	0		8.2 J	8.2	54.6 J	30400	77.5 J	495	0.31 J	0.6 J	1170
CUA01615	LK	10	08/05/1998	0		6 J		64.2	22100	29.3				150
CUA01615	LK	10	08/05/1998	0	0.68 UJ						296	0.18 J	2.2	
CUA01616	LK	10	08/05/1998	0	0.69 UJ	5.4 J	0.63 J	34.4	21100	33.7	199	0.11 J	2.2 U	179
CUA01617	LK	10	08/05/1998	0	0.71 UJ	7.5 J	0.63 J	65.8	21300	27.9	467	0.09 J	2.4 U	213
CUA01618	LK	10	08/05/1998	0								0.28 J		
CUA01618	LK	10	08/05/1998	0	0.73 J	5.8 J	10.9	53.8	20400	150	776		2.3	1130
CUA01619	LK	10	08/05/1998	0	0.67 UJ	5.4 J	9.4	282	18300	143	839	0.25 J	3.1 U	1030
CUA0162	LK	10	08/05/1998	0		6 J	2.3	28.3 J	24800	62.8 J	254	0.1 UJ	0.48 J	662
CUA01620	LK	10	08/05/1998	0	0.75 J	8.9 J	10.3	34.9	21600	128	726	0.05 UJ	4.9	1170
CUA01621	LK	10	08/05/1998	0	0.69 UJ	2.6 J	6.9	35.4	13300	116	482	0.1 J	1.4 U	868
CUA0163	LK	10	08/05/1998	0		6.1 J	3.7	28.6 J	27300	54.1 J	360	0.1 UJ	0.59 J	863
CUA0164	LK	10	08/05/1998	0		5.7 J	2.6	50.2 J	20900	46.5 J	182	0.17 UJ	0.26 J	537
CUA0165	LK	10	08/05/1998	0		5.5 J	4	106 J	26100	100 J	304	0.11 UJ	0.29 J	1170
CUA0166	LK	10	08/05/1998	0	0.8 J	4.9 J	9.8	33.2	22700	117	617	0.26 J	2.2 U	1130

# Data Summary Table

## Coeur d'Alene Lake - segment CDALakeSeg03

Boxed Sample Results Exceed  
Screening Level By More Than 1X

Shaded Sample Results Exceed Screening  
Level By More Than 10X

Shaded Results With (\*) Exceed  
Screening Level By More Than 100X

Location	Location Type	Ref	Date	Depth In Feet	Antimony	Arsenic	Cadmium	Copper	Iron	Lead	Manganese	Mercury	Silver	Zinc
<b>Sediment (mg/kg)</b>														
CUA0167	LK	10	08/05/1998	0	2.4 J	7.1 J	11.5	283	20100	180	671	0.09 J	3.3 U	1250
LC10153	RV	16	---	1.15	32	100	* 78	96	55000	2650	4800	2.2	7	4900
LC10154	RV	16	---	1.22	58	120	* 88	150	55000	4170	3200	3.3	11	6500
LC10155	RV	16	---	1.09	40	110	* 100	91	50000	1850	7200	2.9	6	5800
LC10156	RV	16	---	1.13	54	160	* 89	132	52000	3070	4400	3.1	9	6200
LC10157	RV	16	---	0.2	35	81	9	106	51000	2490	4100	2.7	7	5400
LC10158	RV	16	---	1.13	21	44	* 85	73	44000	1290	3200	1.7	3	4500
LC10159	RV	16	---	0.81	20	66	* 76	70	42000	1230	2900	1.4	3	4300
LC10160	RV	16	---	0.39	6	33	46	42	38000	540	2400	0.47	1	2800
LC10161	RV	16	---		1	9	6	9	19000	50	500	0.32	1 U	420
LC10219	RV	16	---	0.36	6	38	43	35	33000	280	100	0.28	1 U	2400
LC10220	RV	16	---	0.33	2	21	24	27	27000	190	700	0.15	1 U	1600
LC10221	RV	16	---	0.88	12	52	57	51	37000	700	2300	0.96	2	3300
LC10222	RV	16	---	0.69	12	73	56	60	50000	1030	3500	1.03	2	3700
LC10223	RV	16	---	0.08	11	59	47	61	46000	980	1900	0.82	2	3100

### Surface Water - Total Metals (ug/l)

CL8108	RV	13	---	0			6	35 U	16		4			3 U
CL8110	RV	13	---				3 U	35 U	220		16			3 U
CL8112	RV	13	---				4	35 U	32		2			51
CL8154	SP	13	---			29 U	7	35 U	12 U	15 U	4	5 U		3 U
CL8157	SP	13	---			29 U	3	35 U	74	15 U	2 U	5 U		4
CL8158	RV	13	---			3.3	4	35 U	12 U	15 U	2 U	5 U		6
CL8159	RV	13	---			29 U	4	35 U	12 U	15 U	2 U	5 U		4
CL8160	AD	13	---			15	7	35 U	710	15 U	350	5 U		680

### Surface Water - Dissolved Metals (ug/l)

CL8108	RV	13	---	0			2.9	18	12		3.9			8
CL8110	RV	13	---				2.3 U	9.7	150		18			2.8
CL8112	RV	13	---				3.2	16	3.7 U		1.2 U			13
CL8154	SP	13	---				2.3 U	8.4 U	20		4.1			2.5 U
CL8157	SP	13	---				2.3 U	8.8	3.7 U		1.2 U			3.8
CL8158	RV	13	---				3	14	3.7 U		1.2 U			11
CL8159	RV	13	---				2.7	14	3.7 U		1.2 U			3.6
CL8160	AD	13	---				4.2	16	550		350			640

**ATTACHMENT 3**  
**Statistical Summary Tables for Metals**

**Statistical Summary of Total Metals Concentrations in Surface Soil**  
**Segment CDALakeSeg01**  
**Units: mg/kg**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Antimony	7	2	1.8	2.2	2	0.14	31.3	0	0	0
Arsenic	7	6	1.8	7	4.08	0.46	12.6	0	0	0
Cadmium	7	4	0.26	0.43	0.363	0.2	9.8	0	0	0
Copper	7	7	8.7	23.4	14.1	0.35	100	0	0	0
Iron	7	7	10,600	29,600	17,700	0.39	27,600	1	0	0
Lead	7	7	8.8	98.2	38.4	0.82	47.3	2	0	0
Manganese	7	7	146	596	351	0.52	1,760	0	0	0
Mercury	7	1	0.54	0.54	0.54	< 0.001	23.5	0	0	0
Zinc	7	7	26.6	119	68.5	0.52	97.1	2	0	0

**Statistical Summary of Total Metals Concentrations in Sediment**  
**Segment CDALakeSeg01**  
**Units: mg/kg**

<b>Analyte Name</b>	<b>Quantity Tested</b>	<b>Quantity Detected</b>	<b>Minimum Detected Value</b>	<b>Maximum Detected Value</b>	<b>Average Detected Value</b>	<b>Coefficient of Variation</b>	<b>Screening Level (SL)</b>	<b>Quantity Exceeding 1X the SL</b>	<b>Quantity Exceeding 10X the SL</b>	<b>Quantity Exceeding 100X the SL</b>
Antimony	27	27	0.5	18	4.87	1.23	3	10	0	0
Arsenic	153	32	2.8	530	56.6	1.96	12.6	12	5	0
Cadmium	153	114	0.33	39	3.91	2.35	0.678	78	12	0
Copper	27	27	9.9	73	37	0.47	28	18	0	0
Iron	153	153	6,910	62,000	23,200	0.47	40,000	14	0	0
Lead	153	153	4.8	2,410	102	3.45	47.3	17	9	0
Manganese	153	153	19.7	13,600	664	2.47	630	22	3	0
Mercury	27	26	0.02	1.8	0.476	1.32	0.179	10	1	0
Silver	27	11	1	7	3.45	0.54	4.5	3	0	0
Zinc	153	153	10.2	3,400	248	2.64	97.1	33	12	0

**Statistical Summary of Total Metals Concentrations in Surface Water**  
**Segment CDALakeSeg01**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Copper	2	1	2.4	2.4	2.4	< 0.001	1	1	0	0
Iron	2	1	243	243	243	< 0.001	300	0	0	0
Lead	22	2	0.17	4.8	2.49	1.31	15	0	0	0
Manganese	2	2	12.5	18.1	15.3	0.26	50	0	0	0
Zinc	23	16	1.1	60	20.1	0.87	30	5	0	0

**Statistical Summary of Dissolved Metals Concentrations in Surface Water**  
**Segment CDALakeSeg01**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Arsenic	2	1	0.28	0.28	0.28	< 0.001	150	0	0	0
Copper	2	1	1.7	1.7	1.7	< 0.001	3.2	0	0	0
Iron	2	1	88.8	88.8	88.8	< 0.001	1,000	0	0	0
Lead	26	4	1	1.01	1	0.01	1.09	0	0	0
Manganese	2	2	7.7	8.6	8.15	0.08	20.4	0	0	0
Zinc	26	4	1	4.2	2.05	0.74	42	0	0	0

**Statistical Summary of Total Metals Concentrations in Surface Soil**  
**Segment CDALakeSeg02**  
**Units: mg/kg**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Antimony	35	23	0.68	2.6	1.66	0.34	31.3	0	0	0
Arsenic	57	57	1.8	210	22.5	2.14	12.6	9	5	0
Cadmium	57	50	0.23	8.3	2.39	0.72	9.8	0	0	0
Copper	57	57	11.1	840	47.8	2.3	100	3	0	0
Iron	57	57	9,920	48,900	22,300	0.38	27,600	12	0	0
Lead	57	57	12.2	8,600	253	4.47	47.3	42	1	1
Manganese	57	57	142	2,600	586	0.68	1,760	1	0	0
Mercury	52	29	0.05	0.49	0.142	0.77	23.5	0	0	0
Silver	52	31	0.3	3.2	1.12	0.75	391	0	0	0
Zinc	57	57	40.7	5,720	475	1.78	97.1	41	7	0

**Statistical Summary of Total Metals Concentrations in Sediment**  
**Segment CDALakeSeg02**  
**Units: mg/kg**

<b>Analyte Name</b>	<b>Quantity Tested</b>	<b>Quantity Detected</b>	<b>Minimum Detected Value</b>	<b>Maximum Detected Value</b>	<b>Average Detected Value</b>	<b>Coefficient of Variation</b>	<b>Screening Level (SL)</b>	<b>Quantity Exceeding 1X the SL</b>	<b>Quantity Exceeding 10X the SL</b>	<b>Quantity Exceeding 100X the SL</b>
Antimony	261	177	0.81	76	16.6	0.95	3	127	30	0
Arsenic	292	289	0.71	660	76.8	1.54	12.6	148	66	0
Cadmium	292	286	0.13	157	30.5	1.35	0.678	267	127	56
Copper	292	292	5.6	215	45.9	0.77	28	155	0	0
Iron	292	292	7,670	91,000	30,600	0.57	40,000	100	0	0
Lead	292	292	15.7	12,100	963	1.38	47.3	230	126	5
Manganese	292	292	87.4	24,600	3,350	1.44	630	142	71	0
Mercury	292	188	0.04	4.9	1.36	0.92	0.179	154	61	0
Silver	292	194	0.2	22.8	3.81	0.98	4.5	69	0	0
Zinc	292	292	37.7	9,100	2,000	1.02	97.1	285	144	0

**Statistical Summary of Total Metals Concentrations in Surface Water**  
**Segment CDALakeSeg02**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Arsenic	4	3	12	380	217	0.87	50	2	0	0
Cadmium	4	3	4	12	7.67	0.53	2	3	0	0
Iron	4	1	71	71	71	< 0.001	300	0	0	0
Lead	4	2	2.2	3	2.6	0.22	15	0	0	0
Manganese	4	2	4	9	6.5	0.54	50	0	0	0
Zinc	4	2	11	690	351	1.37	30	1	1	0

**Statistical Summary of Dissolved Metals Concentrations in Surface Water**  
**Segment CDALakeSeg02**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Cadmium	4	2	3.3	7.1	5.2	0.52	0.38	2	1	0
Copper	4	1	15	15	15	< 0.001	3.2	1	0	0
Manganese	4	1	4	4	4	< 0.001	20.4	0	0	0
Zinc	4	4	6	670	174	1.9	42	1	1	0

**Statistical Summary of Total Metals Concentrations in Surface Soil**  
**Segment CDALakeSeg03**  
**Units: mg/kg**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Arsenic	4	4	83	2,500	943	1.19	12.6	4	3	1
Cadmium	4	4	3.3	7.1	5.08	0.31	9.8	0	0	0
Copper	4	4	48	170	100	0.6	100	2	0	0
Iron	4	4	39,000	77,000	55,300	0.31	27,600	4	0	0
Lead	4	4	82	2,300	906	1.15	47.3	4	2	0
Manganese	4	4	280	1,700	730	0.9	1,760	0	0	0
Zinc	4	4	100	420	250	0.54	97.1	4	0	0

**Statistical Summary of Total Metals Concentrations in Sediment**  
**Segment CDALakeSeg03**  
**Units: mg/kg**

<b>Analyte Name</b>	<b>Quantity Tested</b>	<b>Quantity Detected</b>	<b>Minimum Detected Value</b>	<b>Maximum Detected Value</b>	<b>Average Detected Value</b>	<b>Coefficient of Variation</b>	<b>Screening Level (SL)</b>	<b>Quantity Exceeding 1X the SL</b>	<b>Quantity Exceeding 10X the SL</b>	<b>Quantity Exceeding 100X the SL</b>
Antimony	24	19	0.73	58	16.6	1.12	3	12	5	0
Arsenic	42	42	2.6	160	27.5	1.38	12.6	13	1	0
Cadmium	42	42	0.34	100	23.1	1.31	0.678	39	25	6
Copper	42	42	9	283	70.2	0.95	28	35	2	0
Iron	42	42	13,300	55,000	29,900	0.39	40,000	9	0	0
Lead	42	42	27	4,170	540	1.77	47.3	34	11	0
Manganese	42	42	100	7,200	1,240	1.31	630	17	1	0
Mercury	42	24	0.09	3.3	0.975	1.11	0.179	19	5	0
Silver	42	33	0.26	11	2.24	1.23	4.5	6	0	0
Zinc	42	42	150	6,500	1,800	1.03	97.1	42	23	0

**Statistical Summary of Total Metals Concentrations in Surface Water**  
**Segment CDALakeSeg03**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Arsenic	5	2	3.3	15	9.15	0.9	50	0	0	0
Cadmium	8	7	3	7	5	0.33	2	7	0	0
Iron	8	5	16	710	210	1.39	300	1	0	0
Manganese	8	5	2	350	75.2	2.05	50	1	0	0
Zinc	8	5	4	680	149	2	30	2	1	0

**Statistical Summary of Dissolved Metals Concentrations in Surface Water**  
**Segment CDALakeSeg03**  
**Units: ug/L**

Analyte Name	Quantity Tested	Quantity Detected	Minimum Detected Value	Maximum Detected Value	Average Detected Value	Coefficient of Variation	Screening Level (SL)	Quantity Exceeding 1X the SL	Quantity Exceeding 10X the SL	Quantity Exceeding 100X the SL
Cadmium	8	5	2.7	4.2	3.2	0.18	0.38	5	1	0
Copper	8	7	8.8	18	13.8	0.25	3.2	7	0	0
Iron	8	4	12	550	183	1.38	1,000	0	0	0
Manganese	8	4	3.9	350	94	1.82	20.4	1	1	0
Zinc	8	7	2.8	640	97.5	2.45	42	1	1	0

**ATTACHMENT 4**  
**Screening Levels**

## SCREENING LEVELS

Based on the results of the human health and ecological risk assessments, 10 chemicals of potential concern (COPCs) were identified for inclusion and evaluation in the RI. The COPCs and appropriate corresponding media (soil, sediment, groundwater, and surface water) are summarized in Table 1. For each of the COPCs listed in Table 1, a screening level was selected.

The screening levels were used in the RI to help identify source areas and media of concern that would be carried forward for evaluation in the feasibility study (FS). The following paragraphs discuss the rationale for the selection of the screening levels.

Applicable risk-based screening levels and background concentrations were compiled from available federal numeric criteria (e.g., National Ambient Water Quality Criteria), regional preliminary remediation goals (PRGs) (e.g., EPA Region IX PRGs), regional background studies for soil, sediment, and surface water, and other guidance documents (e.g., National Oceanographic and Atmospheric Administration freshwater sediment screening values). Selected RI screening levels are listed in Tables 2 through 4.

For the evaluation of site soil, sediment, groundwater, and surface water chemical data, the lowest available risk-based screening level for each media was selected as the screening level. If the lowest risk-based screening level was lower than the available background concentration, the background concentration was selected as the screening level.

Groundwater data are screened against surface water screening levels to evaluate the potential for impacts to surface water from groundwater discharge.

For site groundwater and surface water, total and dissolved metals data are evaluated separately. Risk-based screening levels for protection of human health (consumption of water) are based on total metals results, therefore, total metals data for site groundwater and surface water were evaluated against screening levels selected from human health risk-based screening levels. Risk-based screening levels for protection of aquatic life are based on dissolved metals results, therefore, dissolved metals data for site groundwater and surface water were evaluated against screening levels selected from aquatic life risk-based screening levels.

**Table 1**  
**Chemicals of Potential Concern**

Chemical	Human Health COPC			Ecological COPC		
	Soil/Sediment	Groundwater	Surface Water	Soil	Sediment	Surface Water
Antimony	X	X				
Arsenic	X	X	X	X	X	
Cadmium	X	X	X	X	X	X
Copper				X	X	X
Iron	X					
Lead	X	X	X	X	X	X
Manganese	X		X			
Mercury			X		X	
Silver					X	
Zinc	X	X	X	X	X	X

**Table 2**  
**Selected Screening Levels for Groundwater and Surface Water—Coeur d'Alene River**  
**Basin and Coeur d'Alene Lake**

Chemical	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Groundwater Total (µg/L)	Groundwater Dissolved (µg/L)
Antimony	6 <sup>a</sup>	2.92 <sup>b</sup>	6 <sup>a</sup>	2.92 <sup>b</sup>
Arsenic	50 <sup>a</sup>	150 <sup>c,d</sup>	50 <sup>a</sup>	150 <sup>c,d</sup>
Cadmium	2 <sup>e</sup>	0.38 <sup>b</sup>	2 <sup>e</sup>	0.38 <sup>b</sup>
Copper	1 <sup>e</sup>	3.2 <sup>c,d</sup>	1 <sup>e</sup>	3.2 <sup>c,d</sup>
Iron	300 <sup>a</sup>	1,000 <sup>c,d</sup>	300 <sup>a</sup>	1,000 <sup>c,d</sup>
Lead	15 <sup>a</sup>	1.09 <sup>b</sup>	15 <sup>a</sup>	1.09 <sup>b</sup>
Manganese	50 <sup>a</sup>	20.4 <sup>b</sup>	50 <sup>a</sup>	20.4 <sup>b</sup>
Mercury	2 <sup>a</sup>	0.77 <sup>c,d</sup>	2 <sup>a</sup>	0.77 <sup>c,d</sup>
Silver	100 <sup>a</sup>	0.43 <sup>c,d</sup>	100 <sup>a</sup>	0.43 <sup>c,d</sup>
Zinc	30 <sup>e</sup>	42 <sup>c,d</sup>	30 <sup>e</sup>	42 <sup>c,d</sup>

<sup>a</sup>40 CFR 141 and 143. National Primary and Secondary Drinking Water Regulations. U.S. EPA Office of Water. Office of Groundwater and Drinking Water. <http://www.epa.gov/OGWDW/wot/appa.html>. October 18, 1999.

<sup>b</sup>Dissolved surface water 95th percentile background concentrations calculated from URS project database.

<sup>c</sup>Freshwater NAWQC for protection of aquatic life are expressed in terms of the dissolved metal in the water column.

<sup>d</sup>Freshwater NAWQC for cadmium, copper, lead, silver, and zinc are expressed as a function of hardness (mg/L of CaCO<sub>3</sub>) in the water column.

Values above correspond to a hardness value of 30 mg/L.

<sup>e</sup>Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. U.S. Department of Energy. Office of Environmental Management. ES/ER/TM-96/R2. Value based on total metals concentration.

Notes:

µg/L - microgram per liter

mg/kg - milligram per kilogram

**Table 3**  
**Selected Screening Levels for Surface Water—Spokane River Basin**

Chemical	SpokaneRSeg01		SpokaneRSeg02		SpokaneRSeg03	
	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)	Surface Water Total (µg/L)	Surface Water Dissolved (µg/L)
Antimony	6 <sup>a</sup>	2.92 <sup>b</sup>	6 <sup>a</sup>	2.92 <sup>b</sup>	6 <sup>a</sup>	2.92 <sup>b</sup>
Arsenic	50 <sup>a</sup>	150 <sup>c</sup>	50 <sup>a</sup>	150 <sup>c</sup>	50 <sup>a</sup>	150 <sup>c</sup>
Cadmium	2 <sup>e</sup>	0.38 <sup>b</sup>	2 <sup>e</sup>	0.38 <sup>b</sup>	2 <sup>e</sup>	0.38 <sup>b</sup>
Copper	1 <sup>e</sup>	2.3 <sup>c,d</sup>	1 <sup>e</sup>	3.8 <sup>c,d</sup>	1 <sup>e</sup>	5.7 <sup>c,d</sup>
Iron	300 <sup>a</sup>	1,000 <sup>c</sup>	300 <sup>a</sup>	1,000 <sup>c</sup>	300 <sup>a</sup>	1,000 <sup>c</sup>
Lead	15 <sup>a</sup>	1.09 <sup>b</sup>	15 <sup>a</sup>	1.09 <sup>b</sup>	15 <sup>a</sup>	1.4 <sup>c,d</sup>
Manganese	50 <sup>a</sup>	20.4 <sup>b</sup>	50 <sup>a</sup>	20.4 <sup>b</sup>	50 <sup>a</sup>	20.4 <sup>b</sup>
Mercury	2 <sup>a</sup>	0.77 <sup>c</sup>	2 <sup>a</sup>	0.77 <sup>c</sup>	2 <sup>a</sup>	0.77 <sup>c</sup>
Silver	100 <sup>a</sup>	0.22 <sup>c,d</sup>	100 <sup>a</sup>	0.62 <sup>c,d</sup>	100 <sup>a</sup>	1.4 <sup>c,d</sup>
Zinc	30 <sup>e</sup>	30 <sup>c,d</sup>	30 <sup>e</sup>	50 <sup>c,d</sup>	30 <sup>e</sup>	75 <sup>c,d</sup>

<sup>a</sup>40 CFR 141 and 143. National Primary and Secondary Drinking Water Regulations. U.S. EPA Office of Water. Office of Groundwater and Drinking Water. <http://www.epa.gov/OGWDW/wot/appa.html>. October 18, 1999.

<sup>b</sup>Dissolved surface water 95th percentile background concentrations calculated from URS project database. Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters. Coeur d'Alene Basin RI/FS. URS. May 2001.

<sup>c</sup>Freshwater NAWQC for protection of aquatic life are expressed in terms of the dissolved metal in the water column.

<sup>d</sup>Freshwater NAWQC for cadmium, copper, lead, silver, and zinc are expressed as a function of hardness (mg/L of CaCO<sub>3</sub>) in the water column.

<sup>e</sup>Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. U.S. Department of Energy. Office of Environmental Management. ES/ER/TM-96/R2. Value based on total metals concentration.

Notes:

µg/L - microgram per liter

mg/kg - milligram per kilogram

**Table 4**  
**Selected Screening Levels—Soil and Sediment**

Chemical	Upper Coeur d'Alene River Basin		Lower Coeur d'Alene River Basin		Spokane River Basin	
	Soil	Sediment	Soil	Sediment	Soil	Sediment
Antimony	31.3 <sup>a</sup>	3.30 <sup>b</sup>	31.3 <sup>a</sup>	3 <sup>c</sup>	31.3 <sup>a</sup>	3 <sup>c</sup>
Arsenic	22 <sup>b</sup>	13.6 <sup>b</sup>	12.6 <sup>b</sup>	12.6 <sup>b</sup>	9.34 <sup>b</sup>	9.34 <sup>b</sup>
Cadmium	9.8 <sup>d</sup>	1.56 <sup>b</sup>	9.8 <sup>d</sup>	0.678 <sup>b</sup>	9.8 <sup>d</sup>	0.72 <sup>b</sup>
Copper	100 <sup>d</sup>	32.3 <sup>b</sup>	100 <sup>d</sup>	28 <sup>c</sup>	100 <sup>d</sup>	28 <sup>c</sup>
Iron	65,000 <sup>b</sup>	40,000 <sup>c</sup>	27,600 <sup>b</sup>	40,000 <sup>c</sup>	25,000 <sup>b</sup>	40,000 <sup>c</sup>
Lead	171 <sup>b</sup>	51.5 <sup>b</sup>	47.3 <sup>b</sup>	47.3 <sup>b</sup>	14.9 <sup>b</sup>	14.9 <sup>b</sup>
Manganese	3,597 <sup>b</sup>	1,210 <sup>b</sup>	1,760 <sup>a</sup>	630 <sup>c</sup>	1,760 <sup>a</sup>	663 <sup>b</sup>
Mercury	23.5 <sup>a</sup>	0.179 <sup>b</sup>	23.5 <sup>a</sup>	0.179 <sup>b</sup>	23.5 <sup>a</sup>	0.174 <sup>c</sup>
Silver	391 <sup>a</sup>	4.5 <sup>c</sup>	391 <sup>a</sup>	4.5 <sup>c</sup>	391 <sup>a</sup>	4.5 <sup>c</sup>
Zinc	280 <sup>b</sup>	200 <sup>b</sup>	97.1 <sup>b</sup>	97.1 <sup>b</sup>	66.4 <sup>b</sup>	66.4 <sup>b</sup>

<sup>a</sup>U.S. EPA Region IX Preliminary Remediation Goals for Residential or Industrial Soil  
<http://www.epa.gov/region09/wasate/sfund/prg>. February 3, 2000.

<sup>b</sup>Technical Memorandum. Estimation of Background Concentration in Soils, Sediments, and Surface Waters.  
Coeur d'Alene Basin RI/FS. URS. May 2001.

<sup>c</sup>Values as presented in National Oceanographic and Atmospheric Administration Screening Quick Reference  
Tables, NOAA HAZMAT Report 99-1, Seattle, WA. M. F. Buchman, 1999. Values generated from numerous  
reference documents.

<sup>d</sup>Final Ecological Risk Assessment. Coeur d'Alene Basin RI/FS. Prepared by CH2M HILL/URS for EPA  
Region 10. May 18, 2001. Values are the lowest of the NOAEL-based PRGs for terrestrial biota (Table ES-3).